A. CHINOOK SALMON

A.1 BACKGROUND AND HISTORY OF LISTINGS

Primary contributor: James M. Myers
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Chinook salmon (*Oncorhynchus tshawytscha* Walbaum), also commonly referred to as king, spring, quinnat, Sacramento, California, or tyee salmon, is the largest of the Pacific salmon (Myers et al. 1998). The species historically ranged from the Ventura River in California to Point Hope, AK in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of Northern Canada (McPhail and Lindsey 1970). Chinook salmon exhibit very diverse and complex life-history strategies. Healey (1986) described 16 age categories for chinook salmon, seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to sockeye salmon (*O. nerka*), although sockeye salmon have a more extended freshwater residence period and utilize different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean predominately within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. This racial approach incorporates life-history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations. For this reason, the BRT has adopted the broader "racial" definitions of ocean- and stream-type for this review.

Of the two life-history types, ocean-type chinook salmon exhibit the most varied and plastic life-history trajectories. Ocean-type chinook salmon juveniles emigrate to the ocean as fry, subyearling juveniles (during their first spring or fall), or as yearling juveniles (during their second spring), depending on environmental conditions. Ocean-type chinook salmon also undertake distinct, coastally oriented, ocean migrations. The timing of the return to freshwater and spawning is closely related to the ecological characteristics of a population's spawning habitat. Five different run times are expressed by different ocean-type chinook salmon populations: spring, summer, fall, late-fall, and winter. In general, early run times (spring and summer) are exhibited by populations that use high spring flows to access headwater or interior regions. Ocean-type populations within a basin that express different runs times appear to have evolved from a common source population. Stream-type populations appear to be nearly obligate yearling outmigrants (some 2-year-old smolts have been identified), they undertake extensive off-shore ocean migrations, and generally return to freshwater as spring-run- or summer-run fish. Stream-type populations are found in northern British Columbia and Alaska, and in the headwater regions of the Fraser River and Columbia River interior tributaries.

Prior to development of the ESU policy (Waples 1991), the NMFS recognized Sacramento River winter-run chinook salmon as a "distinct population segment" under the ESA (NMFS 1987). Subsequently, in reviewing the biological and ecological information concerning

West Coast chinook salmon, Biological Review Teams (BRTs) have identified additional ESUs for chinook salmon from Washington, Oregon, and California: Snake River fall-run (Waples et al. 1991), Snake River spring- and summer-run (Matthews and Waples 1991), and Upper Columbia River summer-run- and fall-run chinook salmon (originally designated as the mid-Columbia River summer-run- and fall-run chinook salmon, Waknitz et al. 1995), Puget Sound chinook salmon, Washington Coast chinook salmon, Lower Columbia River chinook salmon, Upper Willamette River chinook salmon, Middle Columbia River spring-run chinook salmon, Upper Columbia River spring-run chinook salmon, Oregon Coast chinook salmon, Upper Klamath and Trinity rivers chinook salmon, Central Valley fall-run and late-fall-run chinook salmon, and Central Valley spring-run chinook salmon (Myers et al. 1998), the Southern Oregon and Northern California chinook salmon, California Coastal chinook salmon, and Deschutes River (NMFS 1999).

Of the 17 chinook salmon ESUs identified by the NMFS, eight are not listed under the United States ESA, seven are listed as threatened (Snake River spring- and summer-run chinook salmon, and Snake River fall-run chinook salmon [Federal Register, Vol. 57, No. 78, April 22, 1992, p. 14653]; Puget Sound chinook salmon, Lower Columbia River chinook salmon, and Upper Willamette River chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]; Central Valley fall-run, and California Coastal chinook salmon [Federal Register, Vol. 64, No. 179, September 16, 1999, p. 5039]), and two are listed as endangered (Sacramento River winter-run chinook salmon [Federal Register, Vol. 59, No. 2, January 4, 1994, p. 440], and Upper Columbia River spring-run chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]).

The NMFS convened a BRT to update the status of listed chinook salmon ESUs in Washington, Oregon, California, and Idaho. The chinook salmon BRT[1] met in January, March and April of 2003 in Seattle, Washington, to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chinook salmon status review included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhaney, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

A.2.1 SNAKE RIVER FALL-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

Snake River fall-run chinook salmon enter the Columbia River in July and August. The Snake River component of the fall chinook salmon run migrates past the Lower Snake River mainstem dams from August through November. Spawning occurs from October through early December. Juveniles emerge from the gravels in March and April of the following year. Snake River fall-run chinook salmon are subyearling migrants, moving downstream from natal spawning and early rearing areas from June through early fall.

Fall-run chinook salmon returns to the Snake River generally declined through the first half of this century (Irving and Bjornn 1981). In spite of the declines, the Snake River basin remained the largest single natural production area for fall-run chinook salmon in the Columbia River drainage into the early 1960s (Fulton 1968). Spawning and rearing habitat for Snake River fall-run chinook salmon was significantly reduced by the construction of a series of Snake River mainstem dams. Historically, the primary spawning fall-run chinook salmon spawning areas were located on the upper mainstem Snake River. Currently, natural spawning is limited to the area from the upper end of Lower Granite Reservoir to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater and Tucannon Rivers, and small mainstem sections in the tailraces of the Lower Snake hydroelectric dams.

Adult counts at Snake River dams are an index of the annual return of Snake River fall-run chinook salmon to spawning grounds. Lower Granite Dam is the uppermost of the mainstem Snake River dams that allow for passage of anadromous salmonids. Adult traps at Lower Granite Dam have allowed for sampling of the adult run as well as for removal of a portion of non-local hatchery fish passing above the dam. The dam count at Lower Granite covers a majority of fall-run chinook salmon returning to the Snake basin. However, Snake River fall-run chinook salmon do return to locations downstream of Lower Granite Dam and are therefore not included in the ladder count. Lyons Ferry Hatchery is located on the mainstem Snake River below both Little Goose and Lower Monumental Dams. Although a fairly large proportion of adult returns from the Lyons Ferry Hatchery program do stray to Lower Granite Dam, a substantial proportion of the run returns directly to the facility. In addition, mainstem surveying efforts have identified relatively small numbers of fall-run chinook salmon spawning in the tailraces of lower Snake River mainstem hydroelectric dams (Dauble et al. 1999).

Lyons Ferry Hatchery was established as one of the hatchery programs under the Lower Snake Compensation Plan administered through the Unites States Fish and Wildlife Service. Snake River fall chinook. Snake River fall-run chinook salmon production is a major program for Lyons Ferry Hatchery, which is operated by the Washington Department of Fish and Wildlife and is located along the Snake River main stem between Little Goose Dam and Lower Monumental Dam. WDFW began developing a Snake River fall-run chinook salmon broodstock in the early 1970s through a trapping program at Ice Harbor Dam and Lower Granite Dam. The Lyons Ferry facility became operational in the mid-1980s and took over incubation and rearing for the Snake River fall chinook mitigation/compensation program.

A.2.1.1 Summary of Previous BRT Conclusions

Previous chinook salmon status reviews (Waples et al. 1991, Myers et al. 1998) identified several concerns regarding Snake River fall-run chinook salmon: steady and severe decline in abundance since the early 1970s; loss of primary spawning and rearing areas upstream of the Hells Canyon Dam complex; increase in non-local hatchery contribution to adult escapement over Lower Granite Dam, and relatively high aggregate harvest impacts by ocean and in-river fisheries.

A.2.1.2 New Data and Updated Analyses

A major Snake River fall-run chinook salmon supplementation effort based upon the Lyons Ferry Snake River fall-run chinook salmon broodstock has been implemented in recent years (Bugert and Hopley, 1989; Bugert et al. 1995). Facilities adjacent to major natural spawning areas have been used to acclimate release groups of yearling smolts. Additional releases of sub-yearlings have been made in the vicinity of the acclimation sites. The level of subyearling releases depends upon the availability of sufficient broodstock to maintain the on-station program and the off-station yearling releases (Table A.2.1.1). Returns in 2000 and 2001 reflect increases in the level of off-station plants and relatively high marine survival rates.

Abundance

The 1999 NMFS status review update noted increases in the Lower Granite Dam counts in the mid-1990s (Figure A.2.1.1), and the upward trend in returns has continued; the 2001 count over Lower Granite Dam exceeded 8,700 adult fall-run chinook salmon. The 1997 through 2001 escapements were the highest on record since the count of 1,000 in 1975. Returns of naturally produced chinook salmon and increased hatchery returns from the Lyons Ferry Hatchery (on-station releases and supplementation program) account for the increase in escapements over Lower Granite Dam (Table A.2.1.2).

Returns classified as natural origin exceeded 2,600 in 2001. The 1997-2001 geometric mean natural-origin count over Lower Granite Dam was 871 fish, approximately 35% of the delisting abundance criteria proposed for this run (2,500 natural-origin spawners averaged over an 8 year period). The largest increase in fall-run chinook salmon returns to the Snake River spawning area was from the Lyons Ferry Snake River stock component. Returns increased from under 200/year prior to 1998 to over 1,200 and 5,300 adults in 2000 and 2001, respectively. The increase includes returns from the on-station release program as well as returns from large supplementation releases above Lower Granite Dam. Smolt releases from the acclimation sites above Lower Granite Dam have been marked. In recent years, large numbers of unmarked subyearling Lyons Ferry fall chinook have been released from the acclimation sites. These fish will contribute to adult returns over Lower Granite Dam, complicating the estimation of natural production rates (WDFW 2003). Escapement over Lower Granite Dam represents the majority of Snake River fall-run chinook salmon returns. In addition, Snake River fall-run chinook salmon returns to the Tucannon River (less than 100 spawners per year based on redd counts) system and to Lyons Ferry Hatchery (recent average returns to the facility have been approximately 1100 fish/year). Small numbers of fall-run chinook salmon redds have also been reported in tailrace areas below the mainstem Snake River dams (Dauble et al. 1999).

Table A.2.1.1. Escapement and stock composition of fall-run chinook salmon at Lower Granite Dam, 1975-2001; stock composition based on mark recoveries from Lower Granite Dam adult trapping (from Henry Yuen (USFWS Vancouver, WA) U.S. v. Oregon Technical Advisory Committee data base). Returning adults produced from naturally spawning parents (regardless of the origin of the parents) are classified as natural origin.

				Stock Composition of Lower Granite Dam Escapement		
Run Year	**Lower Granite Dam Count**	**Marked Fish to Lyons Ferry Hatchery**	**Lower Granite Dam Escapement**	**Natural-Origin**	**Hatchery-Origin (Snake River)**	**Hatchery-Origin (Non-Snake River)**
1975	1000		1000	1000		
1976	470		470	470		
1977	600		600	600		
1978	640		640	640		
1979	500		500	500		
1980	450		450	450		
1981	340		340	340		
1982	720		720	720		
1983	540		540	428	112	
1984	640		640	324	310	6
1985	691		691	438	241	12
1986	784		784	449	325	10
1987	951		951	253	644	54
1988	627		627	368	201	58
1989	706		706	295	206	205
1990	385	50	335	78	174	83
1991	630	40	590	318	202	70
1992	855	187	668	549	100	19
1993	1170	218	952	742	43	167
1994	791	185	606	406	20	180
1995	1067	430	637	350	1	286
1996	1308	389	919	639	74	206
1997	1451	444	1007	797	20	190
1998	1909	947	962	306	479	177
1999	3381	1519	1862	905	879	78
2000	3830	1372	2458	857	1278	323
2001	10782	2064	8718	2652	5330	736

Table A.2.1.2. Fall chinook hatchery releases into the Snake River basin. All releases are from Lyons Ferry Hatchery-origin broodstock. On station releases and acclimation site "Yearling" releases are marked or tagged; acclimation site "Sub-yearling" releases are generally unmarked (1994-2001 data are from Milks et al. (2003); 1985-1993 release data are from the Fish Passage Center Hatchery database.

			Acclimation Sites							
	Lyons Ferry (Direct)		**Pittsburg Landing**		**Capt. John**		**Big Canyon (Clearwater R.)**		**Hells Canyon Dam**[1]	
Release Year	**Yearling**	**Sub-yearling**	**Yearling**	**Sub-yearling**	**Yearling**	**Sub-yearling**	**Yearling**	**Sub-yearling**	**Yearling**	**Sub-yearling**
1985	650,300	539,392	-	-	-	-	-	-	-	-
1986	481,950	1,789,566	-	-	-	-	-	-	-	-
1987	386,600	1,012,500	-	-	-	-	-	-	-	-
1988	407,500	4,563,500	-	-	-	-	-	-	-	-
1989	413,017	1,710,865	-	-	-	-	-	-	-	-
1990	436,354	3,043,756	-	-	-	-	-	-	-	-
1991	224,439	-	-	-	-	-	-	-	-	-
1992	689,601	-	-	-	-	-	-	-	-	-
1993	206,775	-	-	-	-	-	-	-	-	-
1994	603,661	-	-	-	-	-	-	-	-	-
1995	349,124	-	-	-	-	-	-	-	-	-
1996	407,503	-	114,299	-	-	-	-	-	-	-
1997	456,872	-	147,316	-	-	-	199,399	252,705	-	-
1998	419,002	-	141,814	-	133,205	-	61,172	-	-	-
1999	432,166	204,194	142,885	-	157,010	-	229,608	347,105	-	-
2000	456,401	196,643	134,709	400,156	131,186	892,847	131,306	890,474	-	-
2001	338,757	199,976	103,741	374,070	101,976	501,129	113,215	856,968	-	115,251

[1] Hells Canyon Dam releases increased to 500,000 in 2002

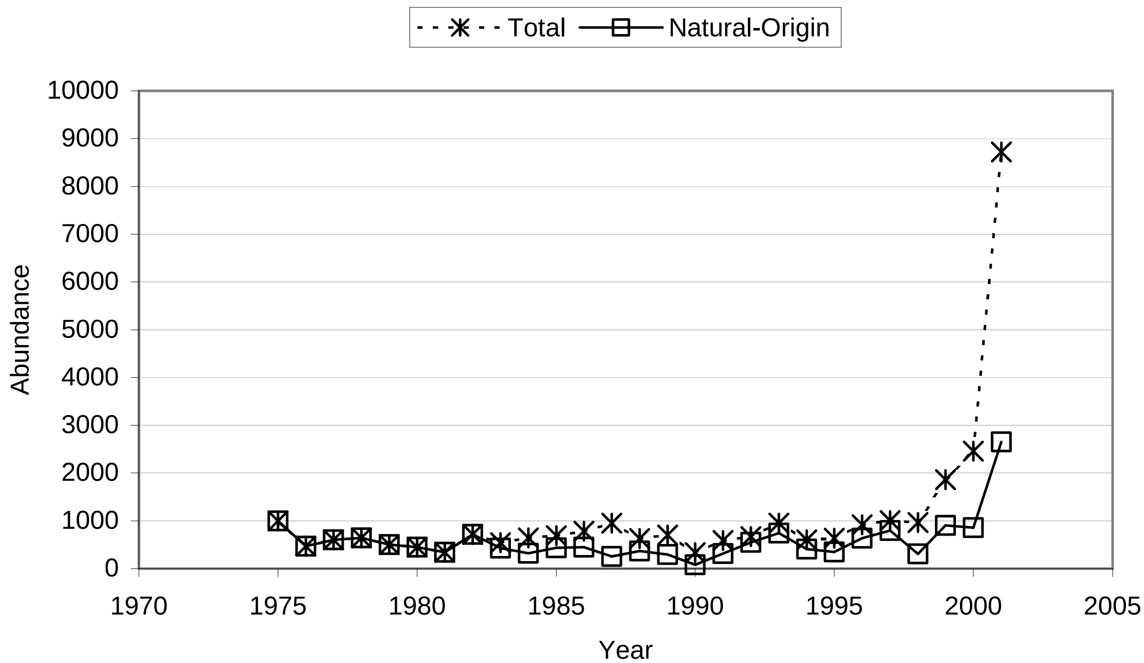

Figure A.2.1.1. Estimated spawning escapement of fall-run chinook salmon at Lower Granite Dam.

Productivity

Both the long-term and short-term trends in total returns are positive (1.05, 1.22). The short-term (1990-2001) estimates of the median population growth rate λ are 0.98 assuming a hatchery spawning effectiveness of 1.0 (equivalent to that of wild spawners) and 1.137 with an assumed hatchery spawning effectiveness of 0. The estimated long-term growth rate for the Snake River fall-run chinook salmon population is strongly influenced by the hatchery effectiveness assumption. If hatchery spawners have been equally as effective as natural-origin spawners in contributing to broodyear returns, the long-term λ estimate is 0.899 and the associated probability that λ is less than 1.0 is estimated as 99%. If hatchery returns over Lower Granite Dam are not contributing at all to natural production (hatchery effectiveness of 0.0), the long-term estimate of λ is 1.024. The associated probability that λ is less than 1.0 is 0.26.

Broodyear return-per-spawner (r/s) estimates were low for three or more consecutive years in the mid-1980s and the early 1990s (Figure A.2.1.2). The large increase in natural abundance in 2000 and 2001 is reflected in the 1996 and 1997 return-per-spawner estimates (1997 r/s is based on 4-year-old component only).

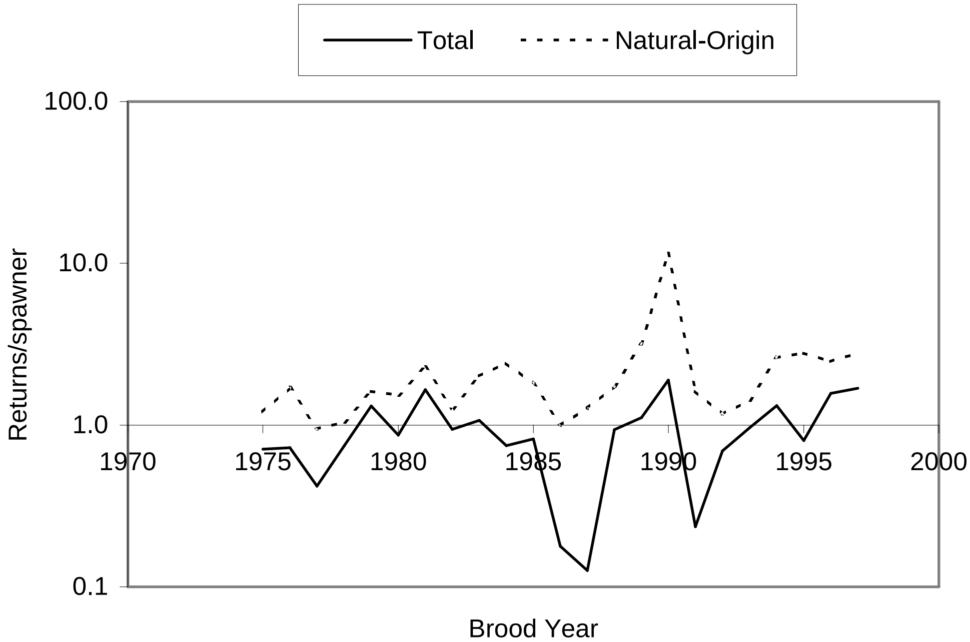

Figure A.2.1.2. Return/spawner plotted against brood year escapements for Snake River fall-run chinook (escapement estimates from Lower Granite Dam counts assuming a 10% pre-spawning mortality; brood year returns estimated by applying sample age at return estimate to annual dam counts.

Harvest impacts

Snake River fall-run chinook salmon are subject to harvest in a wide range of fisheries due to their patterns of ocean distribution and the timing of their spawning run up the Columbia River. Coded-wire tag studies using Lyons Ferry Hatchery fish of Snake River origin indicate that Snake River fall-run chinook salmon have a broad distribution. Recoveries of tagged fish from the Snake River have been reported from coastal fisheries from California, Oregon, Washington, British Columbia and Southeast Alaska. The timing of the return and upriver spawning migration of Snake River fall-run chinook salmon overlaps with the Hanford Reach up-river bright chinook salmon returns as well as with several large hatchery runs returning to lower river release areas or to the major hatcheries adjacent to the lower mainstem Columbia River.

Harvest impacts on Snake River fall-run chinook salmon declined after listing and have remained relatively constant at approximately 35-40% in recent years (Figure A.2.1.3). The decline and subsequent listing of Snake River fall-run chinook salmon prompted major restrictions on U. S. fisheries impacting this stock. In-river gillnet and sport fisheries are ‘shaped’ in time and space to maximize the catch of harvestable hatchery and natural (Hanford Reach) stocks while minimizing impacts on the intermingled Snake River fall-run chinook salmon. Reductions in ocean fishery impacts on Snake River fall-run chinook salmon resulted from management measures designed to protect weakened or declining stocks specific to each set of fisheries.

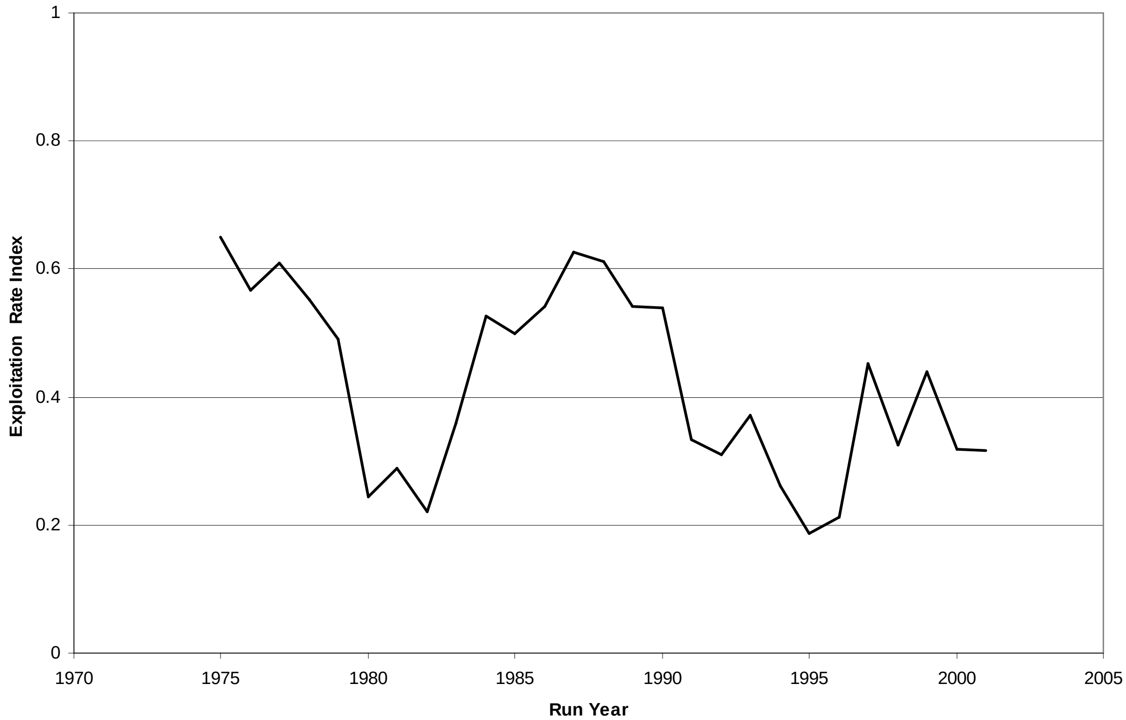

Figure A.2.1.3. Aggregate (ocean and in-river fisheries) exploitation rate index for Snake River fall chinook. Data from Marmorek et al. 1998; 1998-2001 data from Columbia River TAC data base (Henry Yuen, pers. comm..).

Mainstem hydropower impacts

Migration conditions for subyearling chinook salmon from the Snake River have generally improved since the early 1990s (FCRPS 2000 Biological Opinion). The lack of baseline data prior to the mid-1990s precludes quantifying the changes.

Habitat

There have been no major changes in available habitat for Snake River fall-run chinook salmon since the previous status review.

A.2.1.5 New Hatchery Information

Hatchery/Natural composition

The composition of the fall chinook run at Lower Granite Dam is determined by sampling marked returns. Since the early 1980s, the run has consisted of three major components: unmarked returns of natural origin, marked returns from the Lyons Ferry Hatchery program, and strays from hatchery programs outside of the mainstem Snake River (Table A.2.2). While all three components of the fall run have increased in recent years, returns of Snake River origin chinook salmon have increased disproportionately to outside hatchery strays. Prior to the 1998/99 status reviews, the five-year average contribution of outside stocks to the escapement over Lower Granite Dam exceeded 26.2%. The most recent five-year average (1997-2001) was 12.4%, with the contribution in 2001 being just over 8%. The drop in relative contribution by outside stocks reflects the disproportionate increase in returns of the Lyons Ferry component, the systematic removal of marked hatchery fish at the Lower Granite Dam trap, and modifications to the Umatilla program to increase homing of fall-run chinook salmon release groups intended to return to the Umatilla River.

The primary contributor of non-ESU strays to Lower Granite Dam continues to be releases from the Umatilla fall-run chinook salmon program (Priest Rapids stock). In addition, returns from the Klickitat fall-run chinook salmon releases have been consistently detected at the Lower Granite Dam adult trap. In 2000-2002, two or three adult chinook salmon with Klickitat coded wire tags were detected in each sampling year (Milks et al. 2003). Recoveries of Umatilla origin adult tags at the Lower Granite trap ranged from 43 to 166 for the same three-year period (Milks et al. 2003).

One of the concerns leading to the listing of Snake River fall-run chinook salmon under the ESA was the possibility of significant introgression due to increased straying by outside stocks into the natural spawning areas above Lower Granite Dam. Removal of all outside origin stock at Lower Granite Dam is not feasible--the trapping operation does not handle 100% of the run at the dam and outside stocks are generally not 100% marked. A genetic analysis of outmigrant smolts produced from spawning above Lower Granite Dam was conducted to evaluate the potential for introgression of outside stocks. Marshall et al. (2000) concluded that distinctive patterns of allelic diversity persisted in the stock, indicating that the natural Snake River fall-run chinook salmon run remains a distinct resource.

Categorizations of Snake River fall-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.2 SNAKE RIVER SPRING/SUMMER-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

Spring and summer chinook salmon runs returning to the major tributaries of the Snake River were classified as an evolutionarily significant unit (ESU) by NMFS (Matthews and Waples 1991). This ESU includes production areas that are characterized by spring-timed returns, summer-timed returns, and combinations from the two adult timing patterns. Runs classified as spring chinook salmon are counted at Bonneville Dam beginning in early March and ending the first week of June; runs classified as summer-run chinook salmon return to the Columbia River from June through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they emigrate up into tributary areas and spawn. In general, spring-run type chinook salmon tend to spawn in higher elevation reaches of major Snake River tributaries in mid- through late August, and summer-run Snake River chinook salmon spawn approximately 1 month later than spring-run fish.

Many of the Snake River tributaries used by spring and summer chinook salmon runs exhibit two major features: extensive meanders through high elevation meadowlands and relatively steep lower sections joining the drainages to the mainstem Salmon (Matthews and Waples 1991). The combination of relatively high summer temperatures and the upland meadow habitat creates the potential for high juvenile salmonid productivity. Historically, the Salmon River system may have supported more than 40% of the total return of spring-run and summer-run chinook salmon to the Columbia River system (e.g., Fulton 1968).

The Snake River spring/summer-run chinook salmon ESU includes current runs to the Tucannon River, the Grand Ronde River system, the Imnaha River and the Salmon River (Matthews and Waples 1991). The Salmon River system contains a range of habitats used by spring/summer-run chinook salmon. The South Fork and Middle Fork tributaries to the Salmon currently support the bulk of natural production in the drainage. Two large tributaries entering above the confluence of the Middle Fork, the Lemhi and Pahsimeroi Rivers, drain broad alluvial valleys and are believed to have historically supported substantial, relatively productive anadromous fish runs. Returns into the upper Salmon River tributaries have re-established following the opening of passage around Sunbeam Dam on the mainstem Salmon River downstream of Stanley, ID. Sunbeam Dam in the Upper Salmon River was a serious impediment to migration of anadromous fish and may have been a complete block in at least some years before its partial removal in 1934 (Waples, et al. 1991).

Current runs returning to the Clearwater River drainages were not included in the Snake River spring/summer-run chinook salmon ESU. Lewiston Dam in the lower main stem of the Clearwater River was constructed in 1927 and functioned as an anadromous block until the early 1940s (Matthews and Waples 1991). Spring and summer chinook salmon runs into the Clearwater system were reintroduced via hatchery outplants beginning in the late 1940s. As a result, Matthews and Waples (1991) concluded that even if a few native salmon survived the hydropower dams, "...the massive outplantings of non-indigenous stocks presumably substantially altered, if not eliminated, the original gene pool."

Spring-run and summer-run chinook salmon from the Snake River basin exhibit stream type life-history characteristics (Healey 1983). Eggs are deposited in late summer and early fall, incubate over the following winter and hatch in late winter/early spring of the following year. Juveniles rear through the summer, overwinter and migrate to sea in the spring of their second year of life. Depending on the tributary and the specific habitat conditions, juveniles may migrate extensively from natal reaches into alternative summer rearing and/or overwintering areas. Snake River spring/summer-run chinook salmon return from the ocean to spawn primarily as 4 and 5 year old fish, after 2 to 3 years in the ocean. A small fraction of the fish return as 3-year-old 'jacks', heavily predominated by males.

A.2.2.1 Summary of Previous BRT Conclusions

The 1991 ESA status review (Mathews and Waples, 1991) of the Snake River spring/summer-run chinook salmon ESU concluded that the ESU was at risk based on a set of key factors. Aggregate abundance of naturally produced Snake River spring/summer-run chinook salmon runs had dropped to a small fraction of historical levels. Short-term projections (including jack counts, habitat/flow conditions in the broodyears producing the next generation of returns) were for a continued downward trend in abundance. Risk modeling indicated that if the historical trend in abundance continued, the ESU as a whole was at risk of extinction within 100 years. The review identified related concerns at the population level within the ESU. Given the large number of potential production areas in the Snake basin and the low levels of annual abundance, risks to individual subpopulations may be greater than the extinction risk for the ESU as a whole. The 1998 chinook salmon status review (Myers et al. 1998) summarized and updated these concerns. Both short and long-term abundance trends had continued downward. The report identified continuing disruption due to the impact of mainstem hydroelectric development including altered flow regimes and impacts on estuarine habitats. The 1998 review also identified regional habitat degradation and risks associated with the use of outside hatchery stocks in particular areas—specifically including major sections of the Grande Ronde River basin.

Direct estimates of annual runs of historical spring/summer-run chinook salmon to the Snake River are not available. Chapman (1986) estimated that the Columbia River produced 2.5 million to 3.0 million spring-run and summer-run chinook salmon per year in the late 1800s. Total spring-run and summer-run chinook salmon production from the Snake River basin contributed a substantial proportion of those returns; the total annual production of Snake River spring-run and summer-run chinook salmon may have been in excess of 1.5 million adult returns per year (Matthews and Waples 1991). Returns to Snake River tributaries had dropped to roughly 100,000 adults per year by the late 1960s (Fulton 1968). Increasing hatchery production contributed to subsequent years' returns, masking a continued decline in natural production.

A.2.2.2 New Data and Updated Analyses

Abundance

Aggregate returns of spring-run chinook salmon (as measured at Lower Granite Dam) showed a large increase over recent year abundances (Figure A.2.2.1). The 1997-2001 geometric mean return of natural-origin chinook salmon exceeded 3,700. The increase was largely driven by the 2001 return—estimated to have exceeded 17,000 naturally produced spring chinook salmon—however, a large proportion of the run in 2001 was estimated to be of hatchery origin (88%). The summer run over Lower Granite Dam has increased as well (Figure A.2.2.2). The 1997-2001 geometric mean total return was slightly more than 6,000. The geometric mean return for the broodyears for the recent returns (1987-96) was 3,076 (Note: does not address hatchery/wild breakdowns of the aggregate run).

Returns in other production areas are shown in Figures A.2.2.3-A.2.2.16 and summarized in Table A.2.2.1. The lowest five-year geometric mean returns for almost all of the individual Snake River spring/summer-run chinook salmon production areas were in the 1990s. Sulphur Creek and Poverty Flats production areas had low five-year geometric mean returns in the early 1980s. Many, but not all, production areas had large increases in return year 2001.

Recent return levels are also compared against interim delisting criteria (abundance) for those production areas with designated levels. (Table A.2.2.1). The interim abundance criteria were suggested by the Snake River Salmon Recovery Team (Bevan et al., 1995) or, in some cases, were developed for use in analyses supporting the Federal Columbia River hydropower system Biological Opinions.

Productivity

Long-term trend and long-term λ estimates were below 1 for all natural production data sets, reflecting the large declines since the 1960s. Short-term trends and λ estimates were generally positive with relatively large confidence intervals (Table A.2.2.1 & Figure A.2.2.17). Grande Ronde and Imnaha data sets had the highest short-term growth rate estimates. Tucannon River, Poverty Flat (did not have 2000 and 2001 included) and Sulphur Creek index areas had the lowest short-term λ estimates in the series. Patterns in returns per spawners for stocks with complete age information (e.g. Minam River) show a series of extremely low return rates in the 1990s followed by increases in the 1995-97 broodyears (Figure A.2.2.18).

Hydropower impacts

Snake River spring/summer-run chinook salmon must migrate past a series of mainstem Snake and Columbia River hydroelectric dams on their migrations to and from the ocean. The Tucannon River population must migrate through six dams; all other major Snake River drainages supporting spring/summer-run chinook salmon production are above eight dams. Earlier status reviews concluded that mainstem Columbia and Snake River hydroelectric projects have resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat.

Table A.2.2.1. Summary of abundance and trend information for Snake River spring/summer-run chinook salmon relative to previous analyses. Five-year geometric means calculated using years 1997 to 2001 unless otherwise noted. Previous natural geomean for 1987-96 period. Interim targets from B. Lohn Apr. 2002 letter to NWPPC. Comparison of current (recent 5 year geometric mean) to interim target only for those production areas with estimated spawners and corresponding interim target (rpm = redds/mile).

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target (#'s)	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Tucannon R.	24	303 (128 – 1012)	80	190	-4.1	-11.0		
Wenaha R. *	36	225 (67 – 586)	82		-9.4	-23.6		
Wallowa R.	95	0.57 redds (0.0 – 29.0)			+11.5			
Lostine R.	95	34 redds (9 – 131)			+12.7			
Minam R.	95	180 (96 – 573)	172	69	+3.3	-14.5		
Catherine Cr.*	44	50 (13 – 262)	22	45	-25.1	-22.5		
Upper Grande Ronde R.*	42	46 (3 – 336)	20		-9.4			
South Fork Salmon R.	91	496 redds (277 – 679)			+1.1	-13.6		
Secesh R.	96	144 redds (38 – 444)			+9.8			
Johnson Cr.	100	131 redds (49 – 444)[1]			-1.5			
Big Creek Springs	100	53 (21 – 296)	53		+5.4	-34.2		
Big Creek Summers	?	5 redds (2 – 58)			+1.7	-27.9		
Loon Cr.	100	27 redds (6 – 255)			+12.2			
Marsh Cr.	100	53 (0 – 164)	53		-4.0			
Bear Valley / Elk Cr.	100	266 (72 – 712)	266		+6.2			
North Fork Salmon **	?	5.6 redds (2.0 – 19.0)						

Table A.2.2.1 (continued).

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Lemhi R.	100	72 redds (35 – 216)			+12.8	-27.4		
Pahsimeroi R.	?	161 (72 – 1097)			+12.8			
E. Fork Springs***	?	0.27 rpm (0.2 – 1.41)			-5.7			
E. Fork Salmon Summers	100	1.22 rpm (0.35 – 5.32)			+0.9	-32.9		
Yankee Fork Springs***	?	0.0 rpm (0.0 – 0.0)			-6.3			
Yankee Fork Summers	100	2.9 redds (1.0 – 18.0)			+4.1			
Valley Cr. Springs	100	7.4 redds (2.0 – 28.0)			+14.9	-25.9		
Valley Cr. Summers****	?	2.14 rpm (0.71 – 9.29)			+5.8	-29.3		
Upper Salmon Springs	?	69 redds (25 – 357)			+5.3			
Upper Salmon Summers***	?	0.24 rpm (0.07 – 0.58)			-3.3			
Alturas Lake Cr.	?	2.7 redds (0 – 18)			+10.2			
Imnaha R.	38	564 redds (194 – 3,041)[1]		216	+12.8	-24.1		
Big Sheep Cr.	3	0.25 redds (0.0 – 1.0)			+0.8			
Lick Cr.	41	1.4 redds (0.0 – 29.0)			+11.7			

* 5 year geometric mean calculated using years 1992 – 1996

** 5 year geometric mean calculated using years 1996 – 2000

*** 5 year geometric mean calculated using years 1993 – 1997

**** 5 year geometric mean calculated using years 1997, 2000 and 2001 only

[1] Expanded redds

Harvest

Harvest impacts on Snake River spring-run chinook salmon are generally low. Ocean harvest rates are also low. Historical harvest estimates reflect the impact of mainstem and tributary in-river fisheries. In response to initial declines in returns, in-river harvests of both chinook spring-run and summer-run chinook salmon were restricted beginning in the early 1970s (Matthews and Waples 1991).

Fishery impacts were further reduced following listing in 1991, with lower harvest rates from 1991-1999. In response to the large increase in returns of spring chinook salmon runs, additional impacts were allowed beginning in 2000. The management agreement providing for increased impacts as a function of abundance also calls for additional reductions if and when runs drop back down below prescribed thresholds[2].

Habitat

Tributary habitat conditions vary widely among the various drainages of the Snake River basin. There is habitat degradation in many areas of the basin reflecting the impacts of forest, grazing and mining practices. Impacts relative to anadromous fish include lack of pools, increased water temperatures, low flows, poor overwintering conditions, and high sediment loads. Substantial portions of the Salmon River drainage, particularly in the Middle Fork, are protected in wilderness areas.

A.2.2.5 New Hatchery Information

Hatchery production

Spring-run and summer-run chinook salmon are produced from a number of artificial production facilities in the Snake River basin (Table A.2.2.2). Much of the production was initiated under the Lower Snake River Compensation Plan. Lyons Ferry Hatchery serves as a rearing station for Tucannon spring-run chinook salmon broodstock. Rapid River Hatchery and McCall Hatchery provide rearing support for a regionally derived summer-run chinook salmon broodstock released into lower Salmon River areas. Two major hatchery programs have operated in the upper Salmon basin—the Pahsimeroi and Sawtooth facilities. Since the mid-1990s, small-scale natural stock supplementation studies and captive breeding efforts have been initiated in the Snake River basin.

Historically, releases from broodstock originating outside of the basin have constituted a relatively small fraction of the total release into the basin. The 1998 chinook salmon status review (Myers et al. 1998) identified concerns regarding the use of the Rapid River Hatchery stock reared at Lookingglass Hatchery in the Grande Ronde River basin. The Rapid River stock was originally developed from broodstock collected from the spring-run chinook salmon returns to historical production areas above the Hells Canyon complex.

[2] Order Approving Interim Management Agreement for Upriver Spring chinook, Summer Chinook and Sockeye. Approved April 5, 2001. U.S. v Oregon. Civil -68-513.

Use of the Rapid River stock in Grande Ronde drainage hatchery programs has been actively phased out since the late 1990s. In addition, a substantial proportion of marked returns of Rapid River stock released in the Grande Ronde have been intercepted and removed at the Lower Granite Dam ladder and at some tributary level weirs. Carcass survey data indicate significant declines in hatchery contributions to natural spawning in areas previously subject to Rapid River stock strays.

Concerns for the high incidence of BKD disease in Snake River basin hatchery facilities were also identified (Myers et al. 1998).

Categorization of Snake River spring/summer-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

Table A.2.2.2. Total hatchery releases of spring and summer chinook into the Snake River Basin. Summarized by stock and release site. Information from Fish Passage Center smolt release data base.

Basin	Stock	Average releases per year		
		1985 - 1989	1990 - 1994	1995 - 2001
Mainstem Snake	Rapid River	405,192	445,411	146,728
	Leavenworth	32,857	-	-
	Lookingglass	-	-	20,622
	Mixed	-	-	29,369
	Mainstem Total	**438,049**	**445,411**	**196,719**
Tucannon	Tucannon River	63,733	108,957	93,742
Mainstem Grande Ronde	Carson	784,785	100,934	-
	Imnaha River	24,700	-	-
	Lookingglass	396,934	-	-
	Rapid River	452,786	642,605	239,756
	Grande Ronde River	-	-	581
Catherine Creek	Carson	60,893	-	-
	Rapid River	-	14,000	-
	Catherine Creek	7,552	-	24,973
	Lookingglass	153,420	-	-
Wallowa	Carson	70,529	-	-
	Lookingglass	55,120	-	-
	Lostine River	-	-	25,847
	Rapid River	-	28,863	-
	Grande Ronde Total	**2,006,718**	**786,401**	**291,158**
Little Salmon	Rapid River	2,374,325	2,631,741	1,552,835
South Fork Salmon	South Fork Salmon River	929,351	1,020,393	888,469
Pahsimeroi	Pahsimeroi River	418,160	479,382	74,934
	Salmon River	55,809	-	40,444
East Fork Salmon	Salmon River	182,598	147,614	6,222
Upper Salmon	Pahsimeroi River	145,100	-	-
	Rapid River	10,020	20,000	-
	Salmon River	1,220,188	1,091,576	96,877
	Salmon River Total	**5,335,551**	**5,390,706**	**2,659,782**
Imnaha	Imnaha River	**98,425**	**339,928**	**269,886**
ESU Total	**All Stocks**	**7,942,476**	**7,071,402**	**3,511,286**

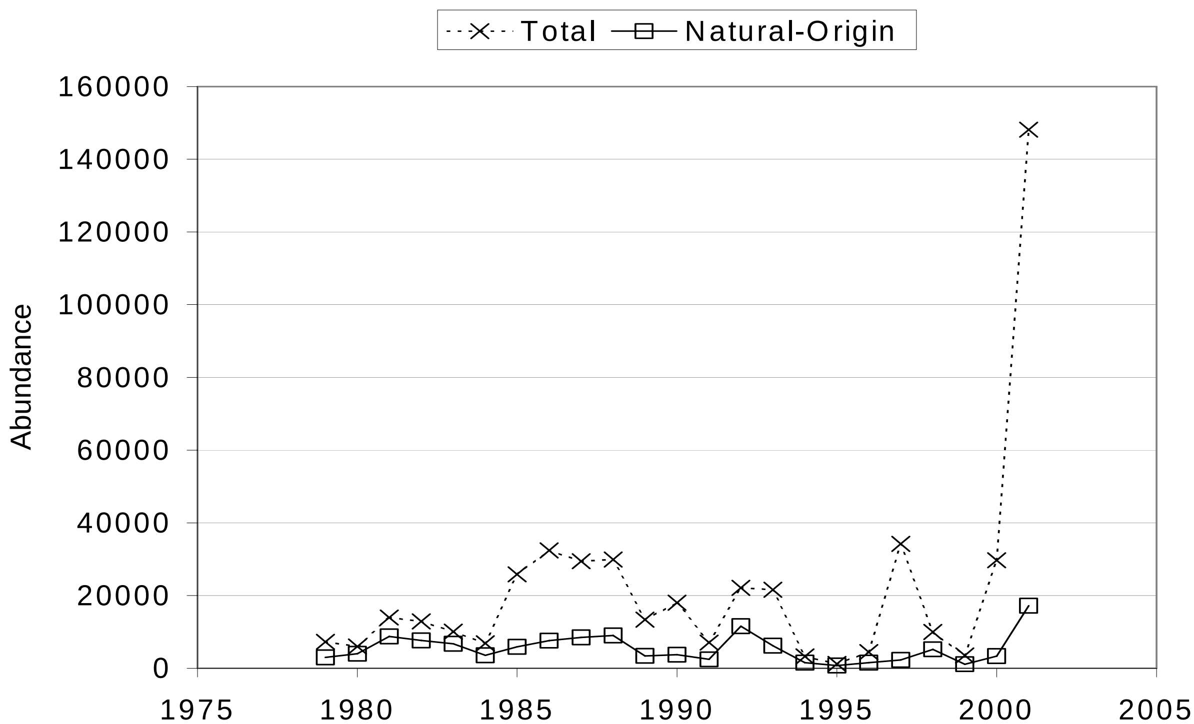

Figure A.2.2.1. Snake River spring-run chinook salmon escapement over Lower Granite Dam.

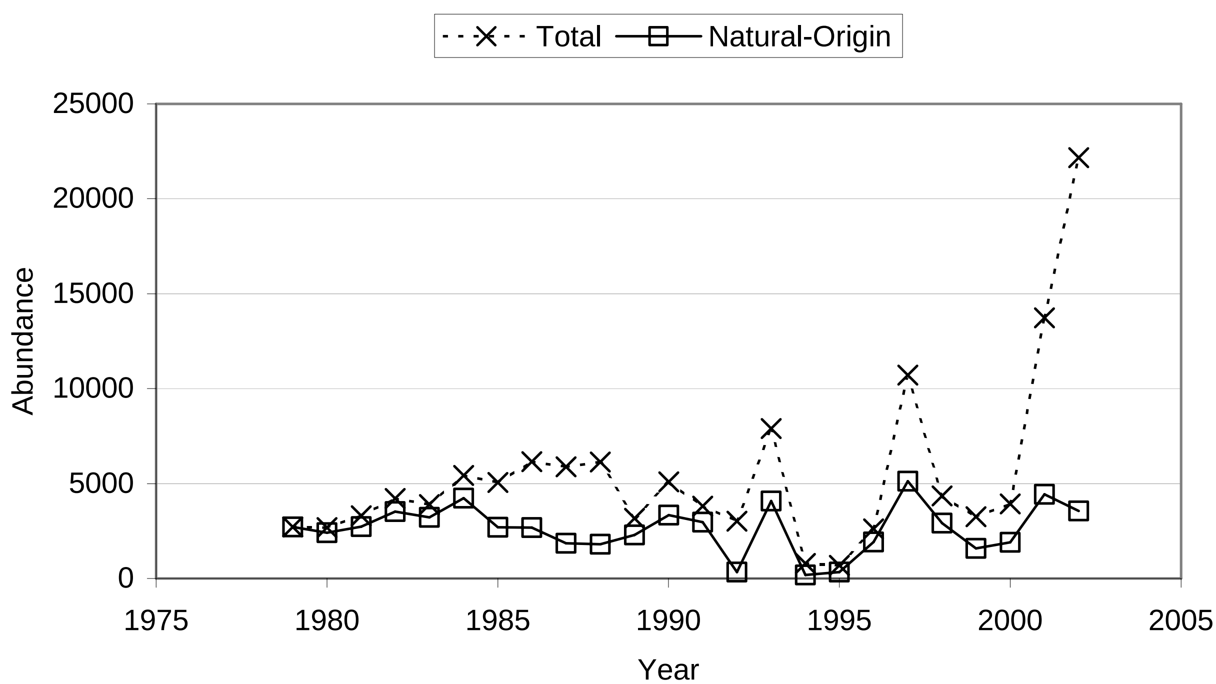

Figure A.2.2.2. Snake River summer-run chinook salmon escapement.

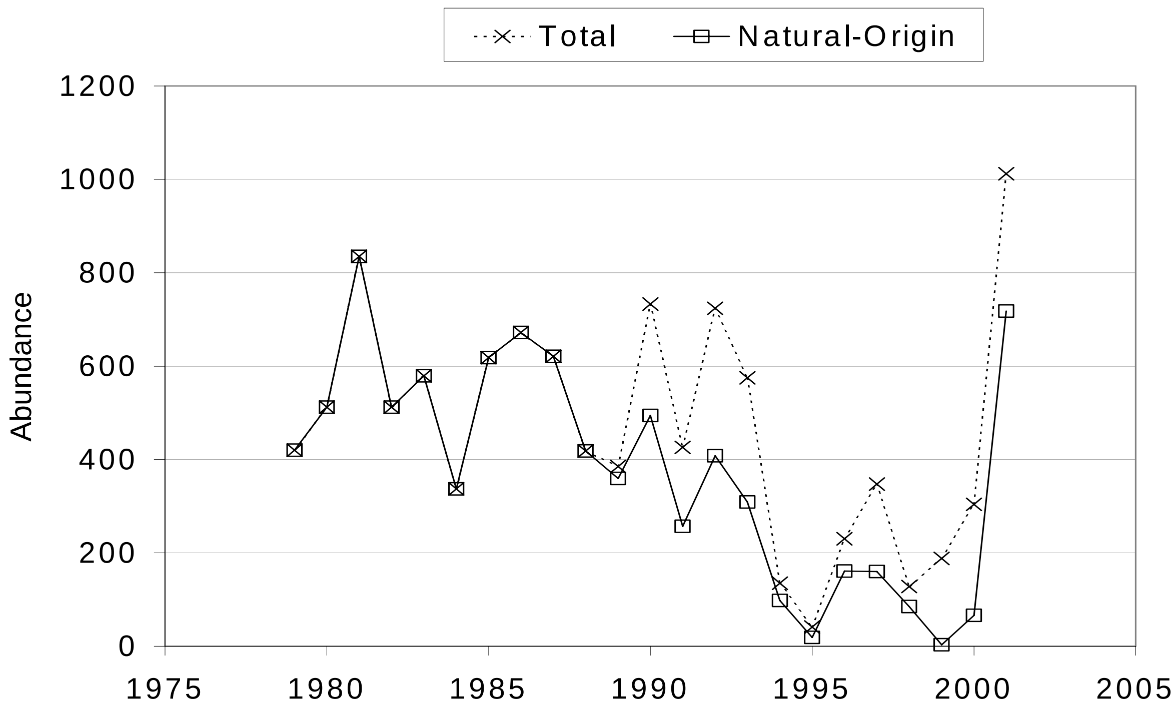

Figure A.2.2.3. Tucannon River spring-run chinook salmon spawning escapement; estimates based on trap counts and expanded redd estimates (WDFW).

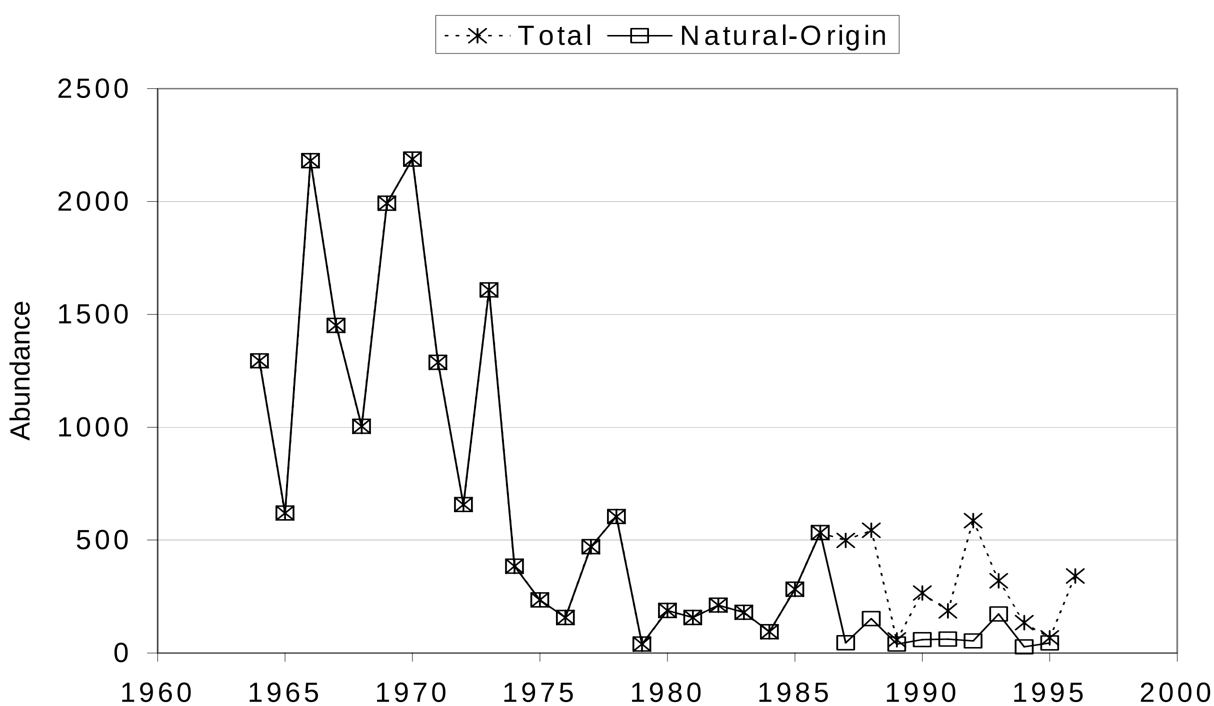

Figure A.2.2.4. Wenaha River spring-run chinook spawning escapement; estimates expanded from redd counts.

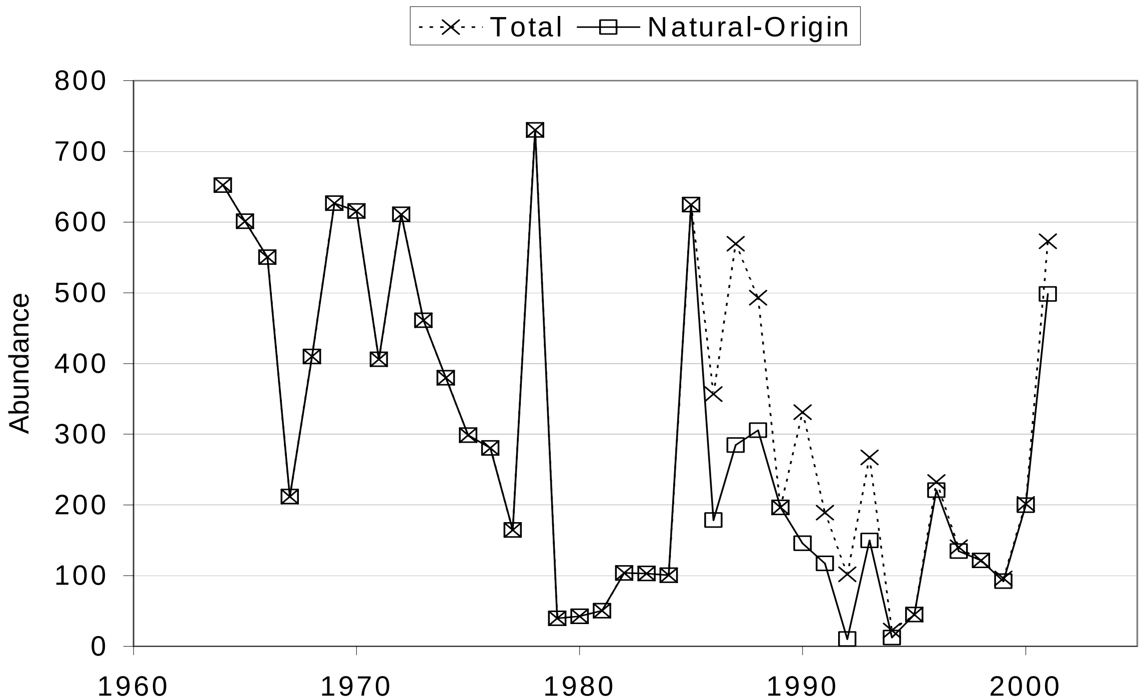

Figure A.2.2.5. Minam River chinook salmon spawning escapements; estimates based on expanded redd counts and carcass sampling (ODFW).

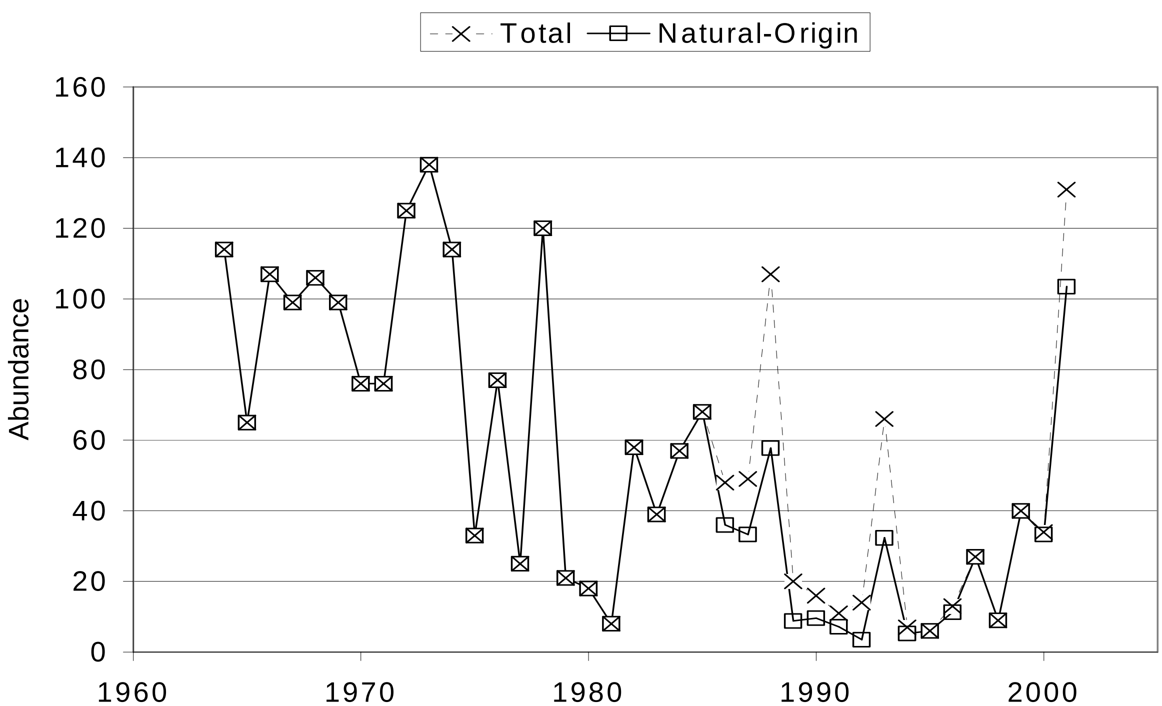

Figure A.2.2.6. Lostine River spring-run chinook salmon total counts; estimates based on redd count expansions and carcass sampling (ODFW).

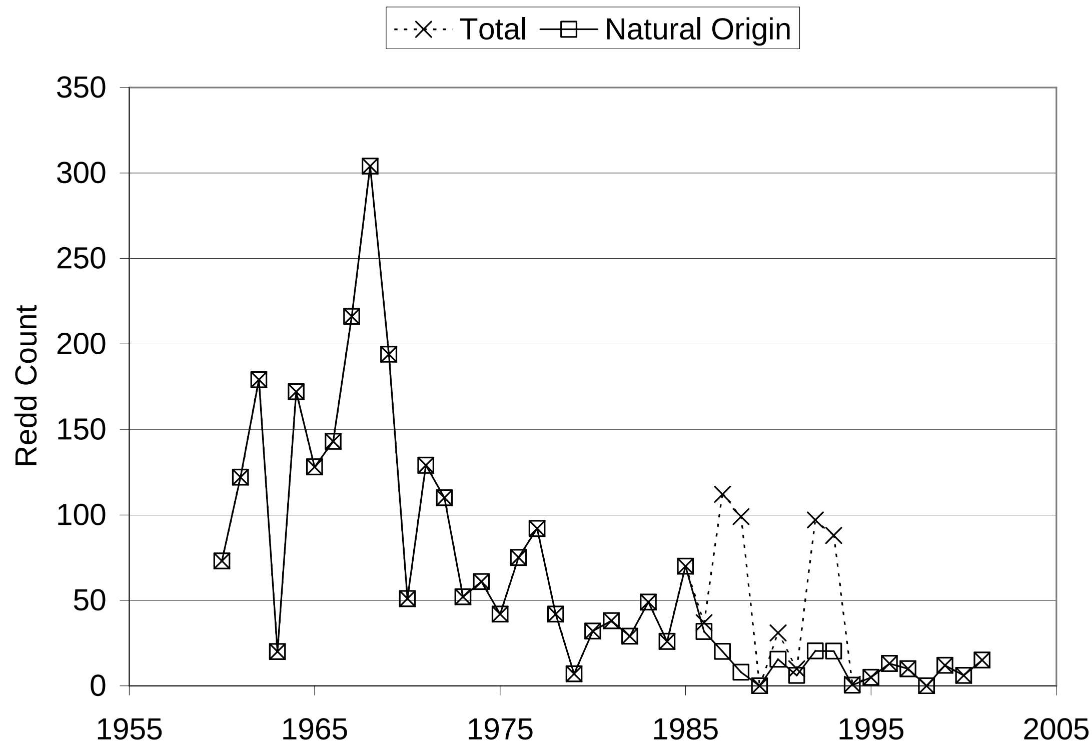

Figure A.2.2.7. Upper Grande Ronde River spring-run chinook redd counts; hatchery contributions based on carcass sampling (ODFW).

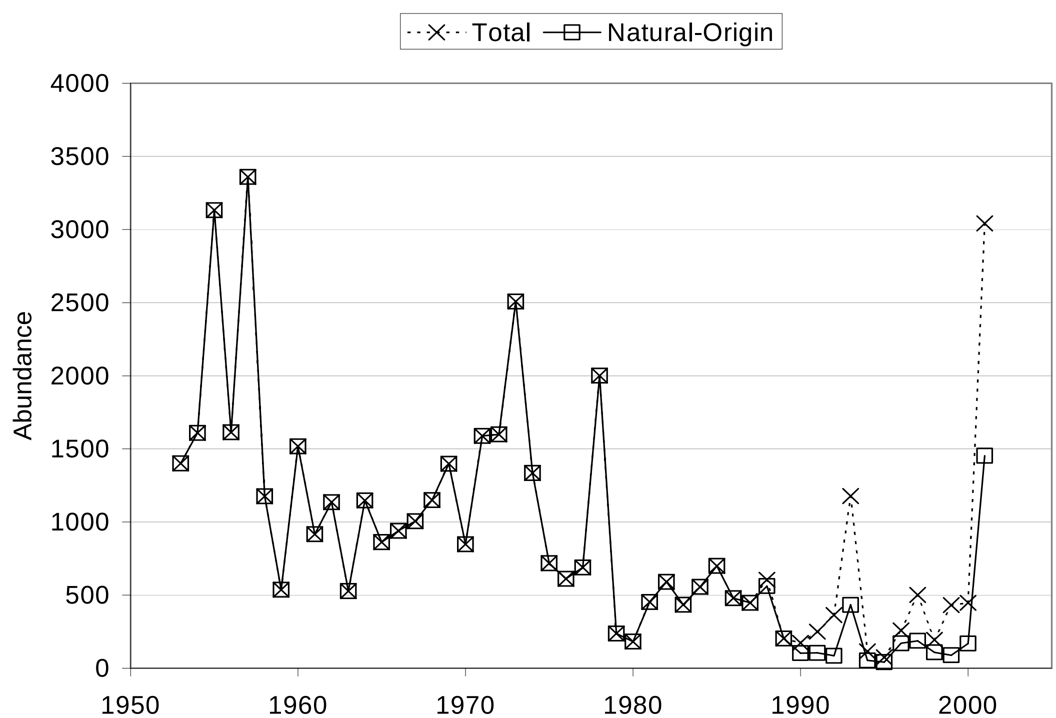

Figure A.2.2.8. Imnaha River spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass sampling (ODFW).

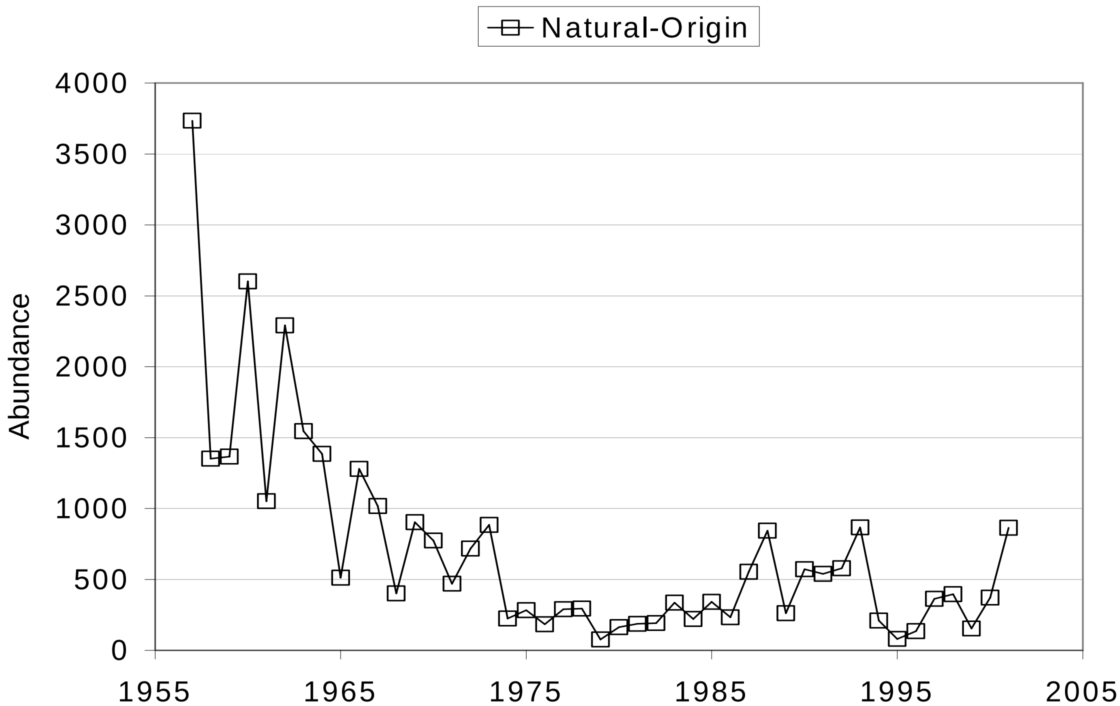

Figure A.2.2.9. Poverty Flat summer-run chinook salmon spawning escapement; estimates based on Idaho Department of Fish and Game (IDFG) redd count expansions.

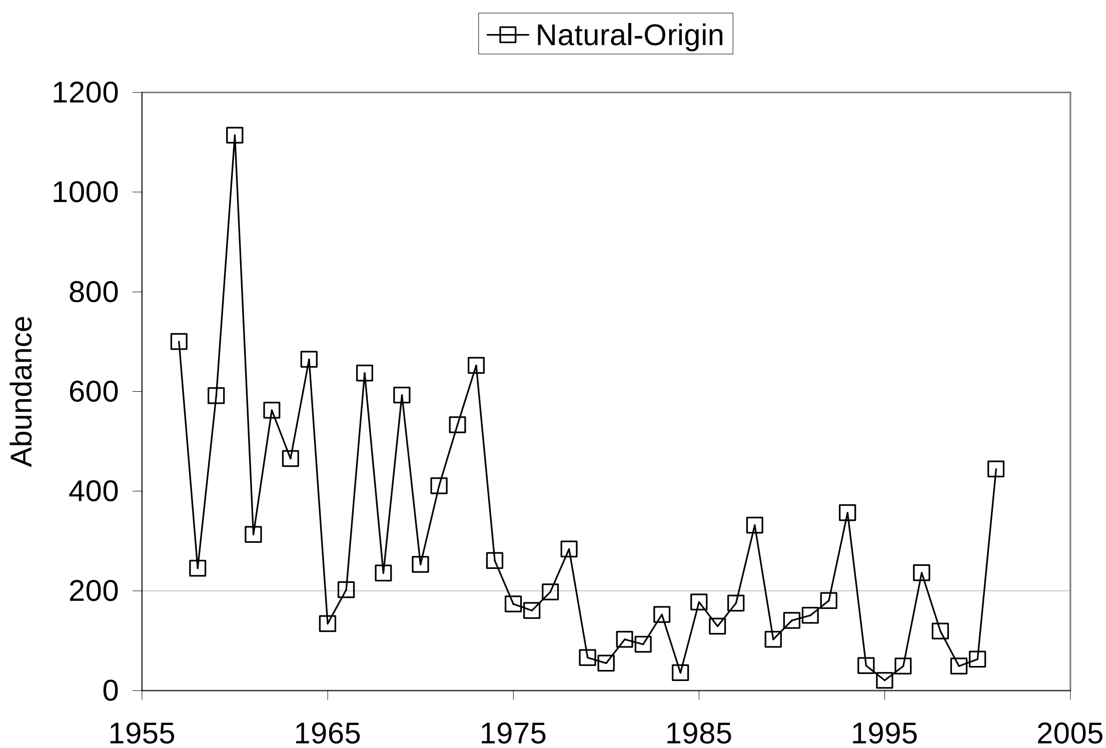

Figure A.2.2.10. Johnson Creek summer-run chinook salmon spawning escapement; estimates based on expanded redd counts (IDFG).

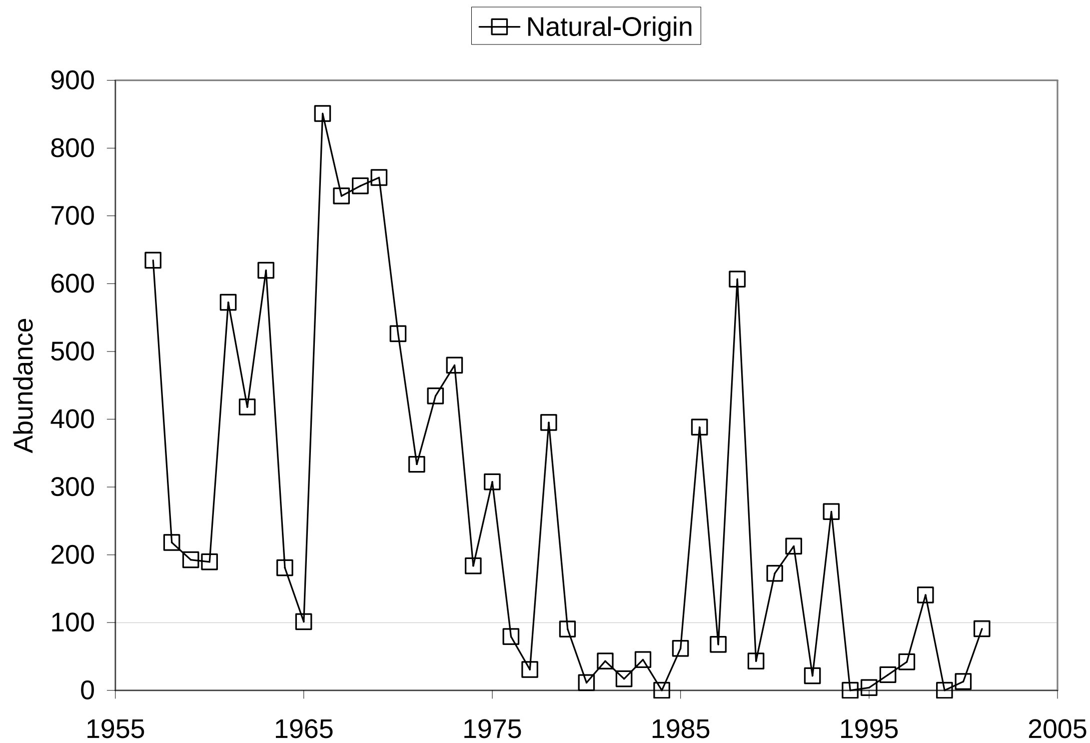

Figure A.2.2.11. Sulphur Creek spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass surveys (IDFG).

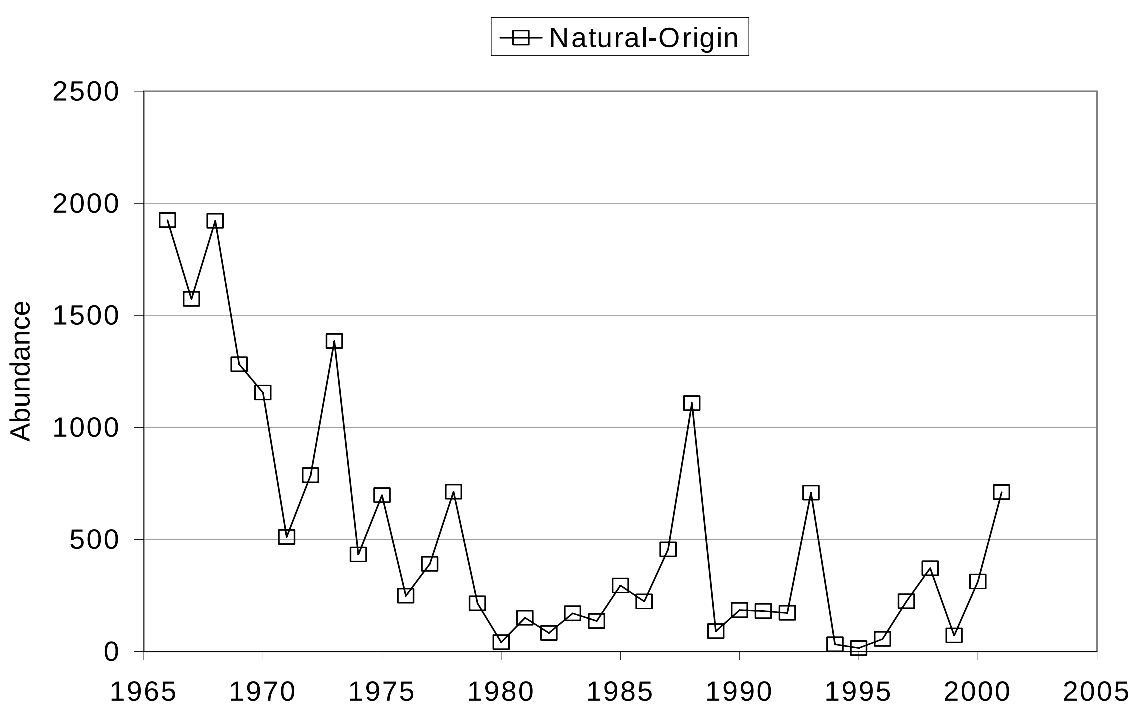

Figure A.2.2.12. Bear Valley/Elk Creek spring chinook spawning escapement; estimates based on expanded redd counts and carcass surveys (IDFG).

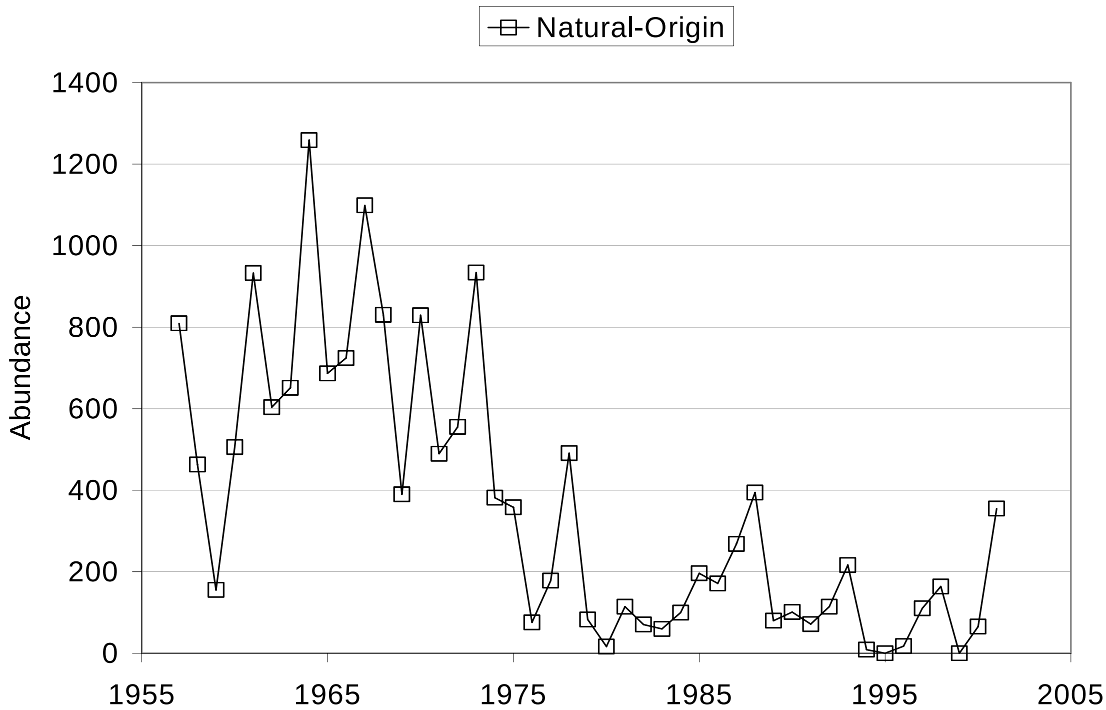

Figure A.2.2.13. Marsh Creek spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass sampling.

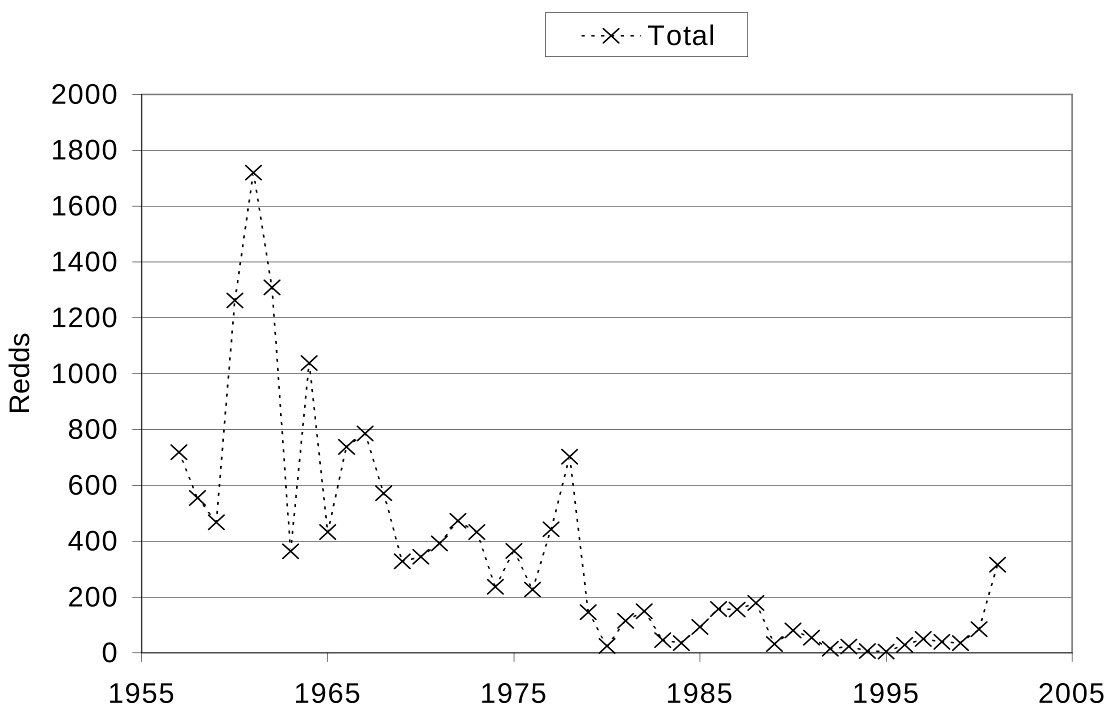

Figure A.2.2.14. Total redd count in the Lemhi River (includes hatchery and natural returns).

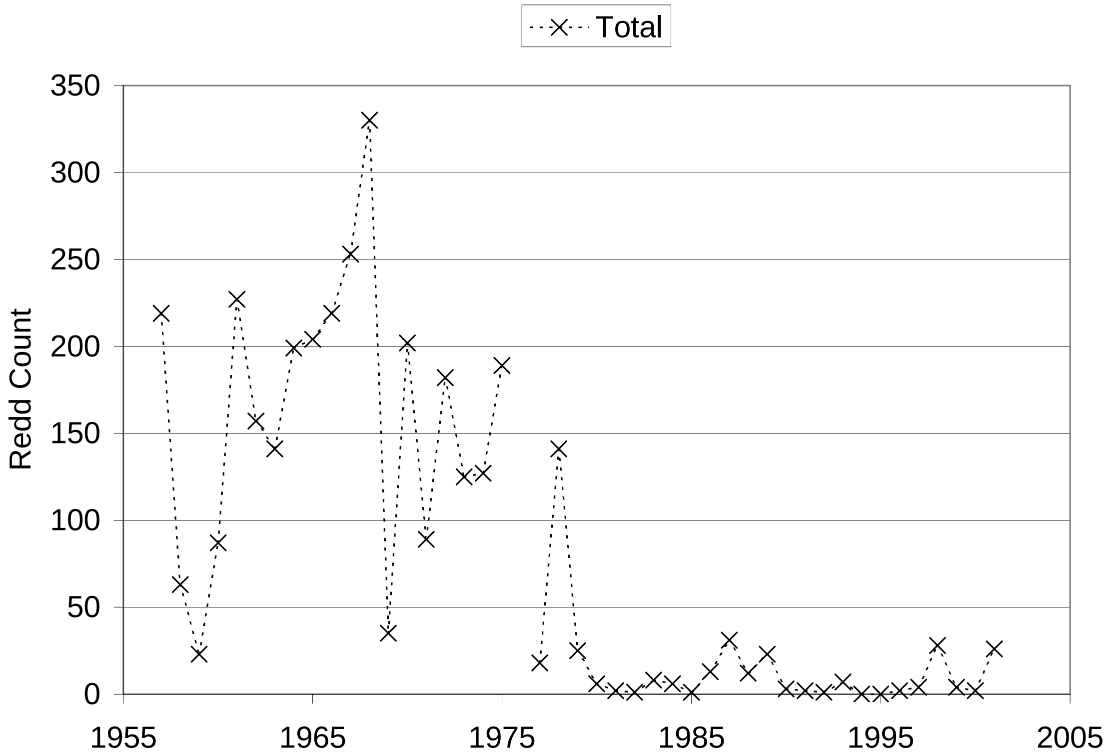

Figure A.2.2.15. Upper Valley Creek spring-run chinook salmon redd counts.

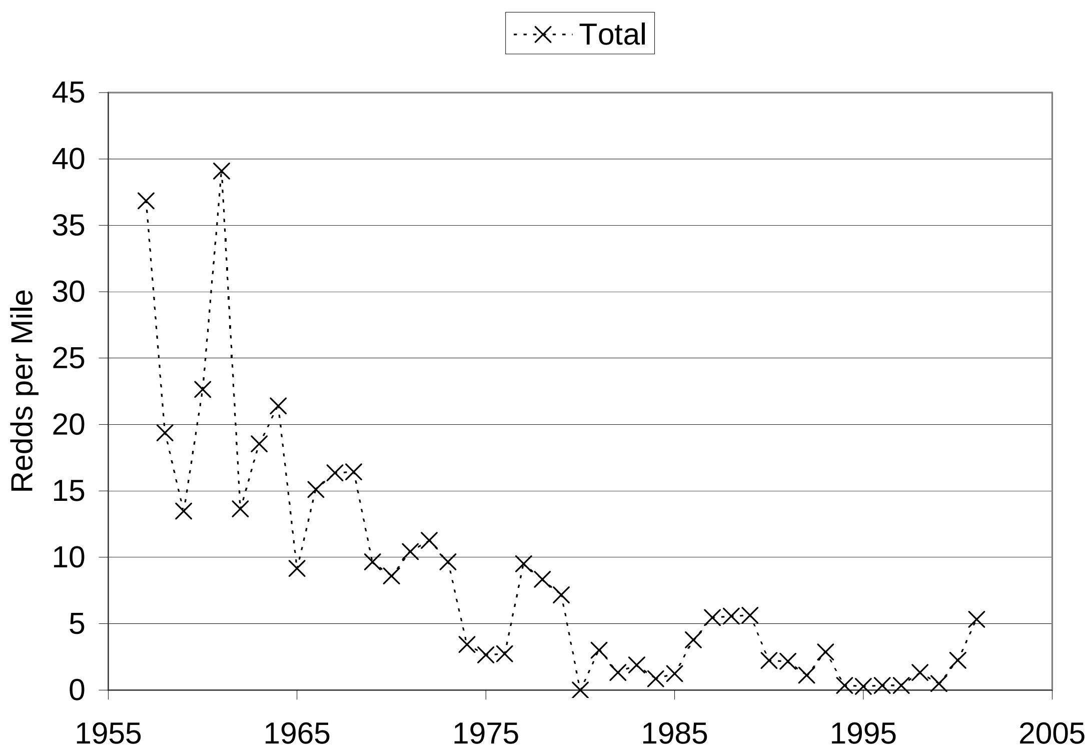

Figure A.2.2.16. East Fork Salmon summer-run chinook salmon redds/mile.

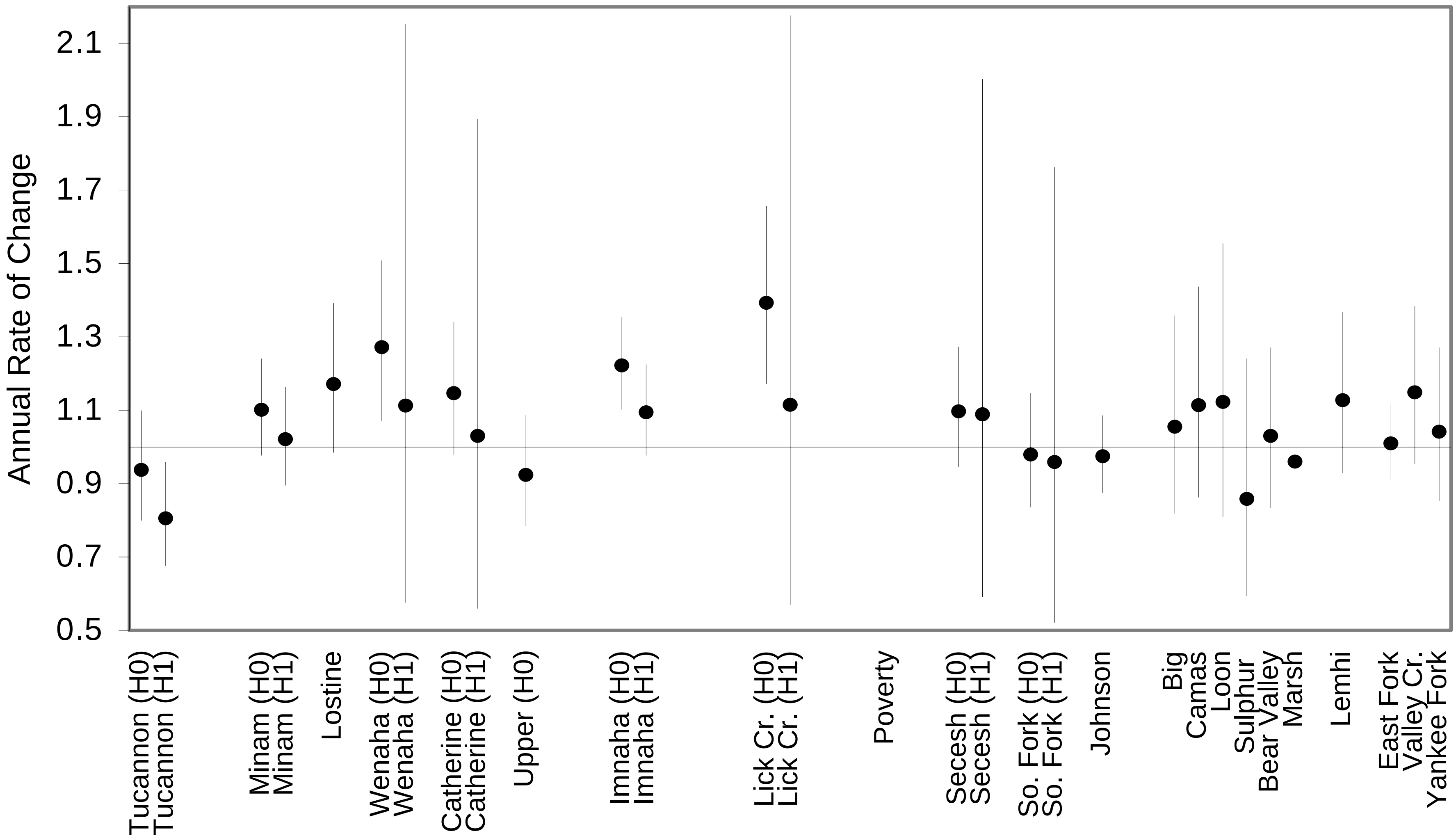

Figure A.2.2.17. Short-term median growth rate (1990-2001) for total spawners for Snake River spring/summer-run production areas. Error bars represent 95% confidence limits of the trend (H0 – hatchery-origin spawners are assumed to have zero reproductive success; H1 – hatchery-origin spawners are assumed to have the same reproductive success as natural-origin fish).

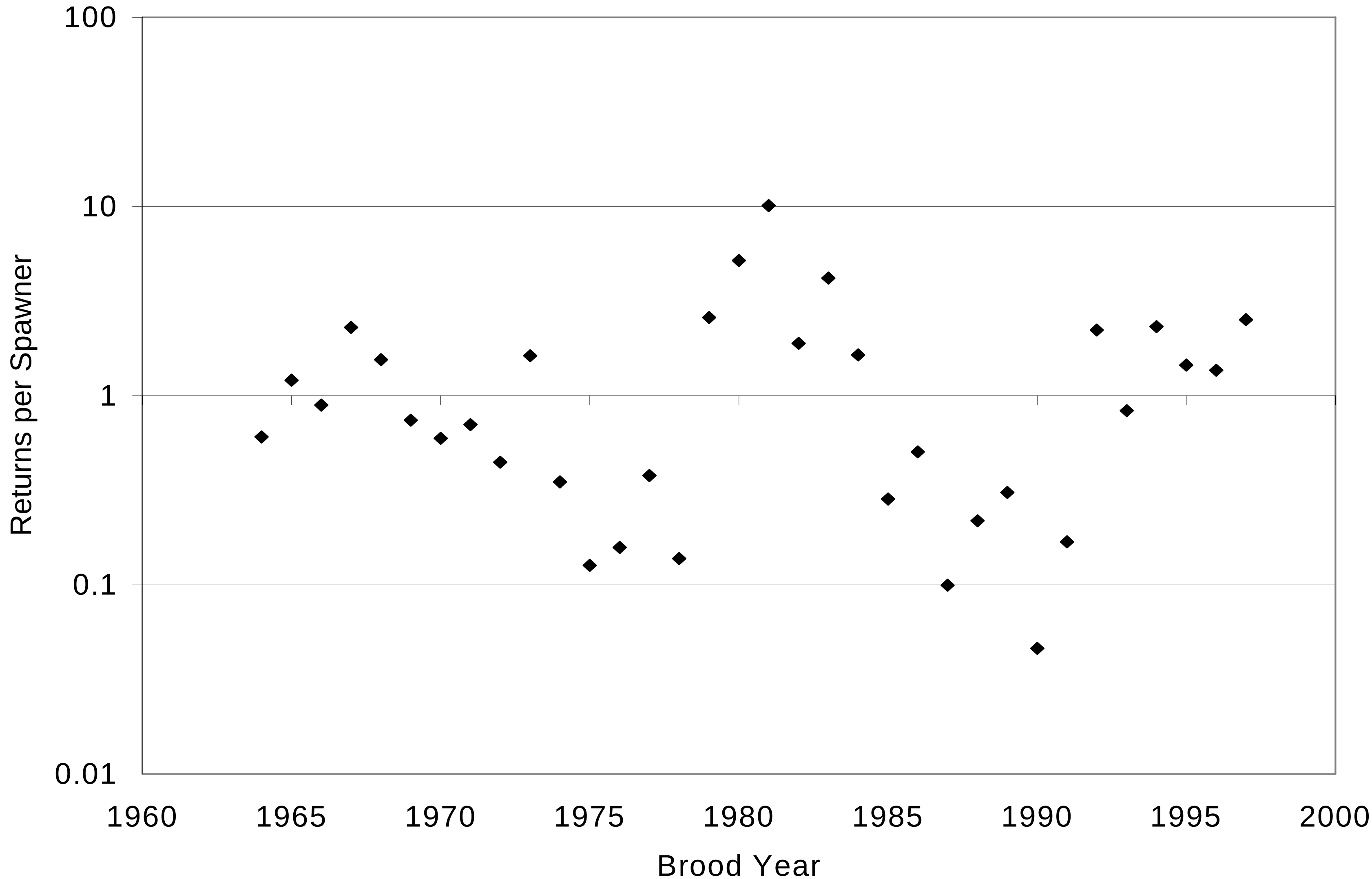

Figure A.2.2.18. Spring/summer chinnok salmon return per spawner for Minam River, calculated as estimated natural returns to the spawning grounds divided by brood year total spawners.

A.2.3 UPPER COLUMBIA RIVER SPRING-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

There are no estimates of historical abundance specific to this ESU prior to the 1930s. The drainages supporting this ESU are all above Rock Island Dam on the upper Columbia River. Rock Island Dam is the oldest major hydroelectric project on the Columbia River; it began operations in 1933. Counts of returning chinook salmon have been made since the 1930s. Annual estimates of the aggregate return of spring-run chinook salmon to the upper Columbia River are derived from the dam counts based on the nadir between spring and summer return peaks. Spring-run chinook salmon currently spawn in three major drainages above Rock Island Dam--Wenatchee, Methow and Entiat Rivers. Historically, spring-run chinook salmon may have also used portions of the Okanogan River.

Grand Coulee Dam, completed in 1938, formed an impassable block to the upstream migration of anadromous fish. Chief Joseph Dam was constructed on the mainstem Columbia River downstream from Grand Coulee Dam and is also an anadromous block. There are no specific estimates of historical production of spring-run chinook salmon from mainstem tributaries above Grand Coulee Dam. Habitat typical of that used by spring-run chinook salmon in accessible portions of the Columbia River basin is found in the middle/upper reaches of mainstem tributaries above Grand Coulee Dam. It is possible that the historical range of this ESU included these areas; alternatively, fish from the upper reaches of the Columbia River may have been in a separate ESU.

Artificial production efforts in the area occupied by the Upper Columbia River spring-run chinook salmon ESU extend back to the 1890s. Hatchery efforts were initiated in the Wenatchee and Methow systems to augment catches in response to declining natural production (e.g., Craig and Soumela 1941). While there are no direct estimates of adult production from early efforts, it is likely contributions were small.

In the late 1930s, the Grand Coulee Fish Maintenance Program (GCFMP) was initiated to address the fact that the completion of the Grand Coulee dam cut off anadromous access above site of the dam. Returning salmonids, including spring-run chinook salmon, were trapped at Rock Island Dam and either transplanted as adults or released as juveniles into selected production areas within the accessible drainages below Grand Coulee Dam. Nason Creek in the Wenatchee system was a primary adult transplantation area in this effort. The program was conducted annually from 1938 until the mid-1940s.

A.2.3.1 Summary of Previous BRT Conclusions

Previous BRT Review

The Upper Columbia River spring-run chinook salmon ESU was reviewed by the BRT in late 1998 (NMFS 1998). “The BRT was mostly concerned about risks falling under the abundance/distribution and trends/productivity risk categories for the ESU...average recent escapement to the ESU has been less than 5,000 hatchery plus wild chinook salmon, and individual populations all consist of less than 100 fish. The BRT was concerned that at these population sizes, negative effects of demographic and genetic stochastic processes are likely to occur. Furthermore, both long- and short-term trends in abundance are declining, many strongly so." The BRT noted that the implementation of emergency natural broodstocking and captive broodstocking efforts for the ESU "...indicate(s) the severity of the population declines to critically small sizes." The BRT recognized that "(h)abitat degradation, blockages and hydrosystem passage mortality all have contributed to the significant declines in this ESU."

A.2.3.2 New Data and Updated Analyses

WDFW, the Yakima Tribe and the Fish and Wildlife Service conduct annual redd count surveys in nine selected production areas within the geographical area encompassed by this ESU (Mosey and Murphy 2002, Hubble and Crampton 2000, Carie 2000). Prior to 1987, redd count estimates were single-survey peak counts. From 1987 on, annual redd counts are generated from a series of on-the-ground counts and represent the total number of redds constructed in any particular year. The agencies use annual dam counts from the mainstem Mid-Columbia River dams as the basis for expanding redd counts to estimates of total spring-run chinook salmon returns. In theWenatchee basin, video counts at Tumwater Dam are available for recent years. Returns to hatchery facilities are subtracted from the dam counts prior to the expansion. Updated returns are summarized in Table A.2.3.1 and in Figures (A.2.3.1-A.2.3.6).

An initial set of population definitions for Upper Columbia River spring-run chinook salmon ESU along with basic criteria for evaluating the status of each population were developed using the Viable Salmonid Population (VSP) guidelines described in McElhany et al. (2000). The definitions and criteria are described in Ford et al. (2000) and have been used in the development and review of Mid-Columbia River PUD plans and the FCRPS Biological Opinion. The interim definitions and criteria are being reviewed as recommendations by the Interior Columbia Technical Recovery Team. Briefly, the joint technical team recommended that the Wenatchee River, the Entiat River and the Methow River be considered as separate populations within the Upper Columbia River Steelhead ESU. The historical status of spring-run chinook salmon production in the Okanogan River is uncertain. The committee deferred a decision on the Okanogan to the Technical Recovery Team. Abundance, productivity and spatial structure criteria for each of the populations in the ESU were developed and are described in Ford et al. (2001).

A.2.3.3 New Hatchery Information

Three national fish hatcheries operated by the U. S. Fish and Wildlife Service are located within the geographic area associated with this ESU. These hatchery programs were established as mitigation programs for the construction of Grand Coulee Dam. Leavenworth National Fish Hatchery, located on Icicle Creek, a tributary to the Wenatchee River system (rkm 42), has released chinook salmon since 1940. Entiat National Fish Hatchery is located on the Entiat River, approximately 10 km upstream of the confluence with the Columbia River mainstem. Spring-run chinook salmon have been released from this facility since 1974. Winthrop National Fish Hatchery is on the Methow River main stem, approximately 72 km upstream of the confluence with the Columbia River. Spring-run chinook salmon were released from 1941-1961, and from 1974 to the present. Initial spring-run chinook salmon releases from these facilities were for the GCFMP project. Leavenworth Hatchery returns served as the principle stock source for all three facilities until the early 1990s. Production was augmented with eggs transferred into the programs from facilities outside of the ESU, primarily Carson Hatchery. Broodstocking for each hatchery program has been switched to emphasize locally returning broodstocks. Management objectives for the Winthrop National Fish Hatchery have been modified to this conservation strategy. The Entiat and Leavenworth Hatchery programs retain the original harvest augmentation objectives, but are managed to restrict interactions with natural populations. Carcass surveys and broodstocking efforts in the upstream natural spawning areas of the Wenatchee River and the Entiat River support the assumption that the stray rate from the downstream hatchery facilities is low—on the order of 1%-5%. Significantly higher contribution rates have been observed in mainstem Methow natural spawning areas, possibly due to the close proximity of the hatchery and to the recent shift to locally adapted stocks.

Additional spring-run chinook salmon hatchery production efforts were initiated in the 1980s as mitigation for smolt losses at mainstem mid-Columbia River projects operated by public utility districts. These programs are aimed at directly supplementing targeted natural production areas in the Wenatchee and Methow River systems. In the Wenatchee River drainage, this program has targeted the Chiwawa River, a major spring chinook production tributary entering at rkm 78.2. Broodstock are collected at a weir located approximately 2 km upstream of the mouth of the Chiwawa River. In some years broodstocking has been augmented by using marked adults collected at Tumwater Dam. Release groups are returned to an acclimation pond adjacent to the lower Chiwawa River for final acclimation and release.

In the Methow River, the supplementation program began in 1992 with broodstock collected from the natural runs to the Chewuch and Twisp Rivers. The Methow Fish Hatchery operated by WDFW has actively managed broodstock collection and mating to maintain separate groups for use in the Chewuch, Twisp and Methow Rivers. In 1996 and again in 1998, extremely low adult returns led to a decision to collect all adults at Wells Dam. Scale reading, elemental scale analysis, and extraction/reading of coded-wire tags have been used at the Methow National Fish Hatchery in support of maintaining broodstock separation.

Beginning in 1998, a composite stock was initiated and the management objectives for Winthrop National Fish Hatchery were established. Since that time, Methow and Winthrop Hatcheries have worked together on broodstock collection and spawning activities. Juveniles are reared at the Winthrop Facility and released into the mainstem Methow River in coordination with releases from acclimation sites on the Twisp River and Chewuch River. The Methow program was initiated with Winthrop Hatchery stock and is being converted to local broodstock. These supplementation programs have had two major impacts on natural production areas. Returns to natural spawning areas have included increasing numbers of supplementation fish in recent years, especially in the Methow mainstem spawning areas adjacent to the hatchery.

The WDFW SASSI report identified nine stocks of spring-run chinook salmon within the upper Columbia River spring-run chinook salmon ESU. Ford et al. (2001) describes the results of applying the population definition and criteria provided in McElhany et al. (2000) to current upper Columbia springRiver spring-run chinook salmon production. The conclusions of the effort were that "...there are (or historically were) three or four independent viable populations of spring-run chinook salmon in the upper Columbia River basin, inhabiting the Wenatchee, Entiat, Methow and (possibly) the Okanogan River basins. There appears to be considerable population substructure within the Wenatchee and Methow basins, however, this substructure should be considered when evaluating recovery goals and management actions."[3]

Hatchery impacts

Hatchery impacts vary among the production areas. Large on-station production programs in the Wenatchee and Entiat River drainages are located in the lower reaches, some distance downstream of natural spawning areas. In the Methow River, Winthrop National Fish Hatchery is located upstream, adjacent to a portion of the mainstem spawning reach for spring-run chinook salmon and steelhead. Straying of returning hatchery-origin adults into the natural production areas is thought to be low for the Wenatchee River and Entiat River. The supplementation programs in the upper Wenatchee and the Methow River basins are designed to specifically boost natural production. In years when the return of natural-origin adults is extremely low, the proportion of hatchery-origin adults on the spawning grounds can be high, even if the dispersal rate of the returning hatchery fish is low. It is likely that returning hatchery fish contribute to spawning in natural production areas in the Methow River at a higher rate. Carcass sampling data are available for a limited number of year/area combinations for the upper Columbia River drainages (e.g., WDF 1992).

Spring-run chinook salmon returns to the Wenatchee and the Methow River systems have included relatively large numbers of supplementation program fish in recent years. The total return to natural spawning areas in the Wenatchee River system for 2001 is estimated to be approximately 4,000-1,200 returning from natural spawning and 2,800 from the hatchery-based supplementation program. The return to spawning areas for the Methow in 2001 is estimated at well over 9,000. Carcass surveys indicate that returning supplementation adults accounted for approximately 80% of the 2001 run to the Methow spawning areas. Supplementation programs have contributed substantially to getting fish on the spawning grounds in recent years. Little information is available to assess the long-term impact of high levels of supplementation on productivity. Categorization for Upper Columbia River spring-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.3.4 Comparison with Previous Data

All three of the existing upper Columbia River spring-run chinook salmon populations have exhibited similar trends and patterns in abundance over the past 40 years. The 1998 Chinook salmon status review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia River spring-run chinook salmon populations were generally negative, ranging from -5% to +1%. Analyses of the data series, updated to include 1996-2001 returns, indicate that those trends have continued. The long-term trend in spawning escapement is

[3]Spring chinook spawning in Icicle Creek, Peshastin Creek, Incgalls Creek and the Leavenworth Hatchery are considered an independent, hatchery-derived population that is not part of the ESU (NMFS 1999).

downward for all three systems. The Wenatchee River spawning escapements have declined an average of 5.6% per year, the Entiat River population at an average of 4.8%, and the Methow River population an average rate of 6.3% per year since 1958. These rates of decline were calculated from the redd count data series[4].

Mainstem spring-run chinook salmon fisheries harvested chinook salmon at rates between 30%-40% per year through the early1970s. Harvest was substantially reduced by restricting mainstem commercial fisheries and sport harvest in the mid-1970s. The calculated downward trend in abundance for the upper Columbia River stocks would be higher if the early redd counts had been revised to reflect the potential 'transfer' from harvest to escapement for the early years in the series.

In the 1960s and 1970s, spawning escapement estimates were relatively high with substantial year-to-year variability. Escapements declined in the early 1980s, then peaked at relatively high levels in the mid 1980s. Returns declined sharply in the late 1980s and early 1990s. Returns in 1990-94 were at the lowest levels observed in the 40-plus years of the data sets. The Upper Columbia Biological Requirements Workgroup (Ford et al. 2001) recommended interim delisting levels of 3,750, 500, and 2,200 spawners for the populations returning to the Wenatchee, Entiat, and Methow drainages, respectively. The most recent 5-year geometric mean spawning escapements (1997-2001) were at 8%-15% of these levels. Target levels have not been exceeded since 1985 for the Methow run and the early 1970s for the Wenatchee and Entiat populations.

Short-term trends for the aggregate population areas reported in the 1998 Status Review (Myers et al. 1998) ranged from -15.3% (Methow R.) to a -37.4% (Wenatchee R.). The Escapements from 1996-1999 reflected that downward trend. Escapements increased substantially in 2000 and 2001 in all three systems. Returns to the Methow River and the Wenatchee River reflected the higher return rate on natural production as well as a large increase in contributions from supplementation programs. Short-term trends (1990-2001) in natural returns remain negative for all three upper Columbia River spring-run chinook salmon populations. Natural returns to the spawning grounds for the Entiat, Methow, and Wenatchee River populations continued downward at average rates of 3%, 10%, and 16% respectively.

Short- and long-term trends in returns to the individual subpopulations within the Wenatchee and Methow systems were consistent with the aggregate population level trends. Long-term and short-term trends for Upper Columbia River spring-run chinook salmon populations are shown in Figures A.2.3.7-A.2.3.8.

McClure et al. (in press) reported standardized quantitative risk assessment results for 152 listed salmon stocks in the Columbia River basin, including representative data sets (1980-2000 return years) for upper Columbia River spring-run chinook salmon. Average annual growth rate

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[4]Prior to 1987, annual redd counts were obtained from single surveys and reported as peak counts. From 1987 on, redd counts were derived from multiple surveys and are reported as annual total counts. An adjustment factor of 1.7 was used to expand the pre-1987 redd counts for comparison with the more recent total counts. (Beamesderfer et al. 1997).

(λ) for the upper spring-run chinook salmon population was estimated as 0.85, the lowest average reported for any of the Columbia River ESUs analyzed in the study. Assuming that population growth rates were to continue at the 1980-2000 levels, upper Columbia River spring-run chinook salmon populations are projected to have a very high probability of a 90% decline within 50 years (0.87 for the Methow River population, 1.0 for the Wenatchee and Entiat runs).

The major harvest impacts on upper Columbia River spring-run chinook salmon have been in mainstem fisheries below McNary Dam and in sport fisheries in each tributary. There are no specific estimates of historical harvest impacts on upper Columbia River spring-run chinook salmon runs. Assuming that upper Columbia River spring-run chinook salmon runs were equally available to mainstem commercial fisheries as were the runs to other areas of the Snake and Columbia rivers, harvest rates in the lower river commercial fisheries were likely on the order of 20%-40% of the in-river run. Lower river harvest rates on up-river spring-run chinook salmon stocks were sharply curtailed beginning in 1980 and were again reduced after the listing of Snake River spring/summer-run chinook salmon in the early 1990s. Sport fishery impacts were also curtailed. Harvest impacts are currently being managed under a harvest management schedule—harvest rates are curtailed even further if the average return drops below a predefined level, increases area allowed at high run sizes.

Mainstem hydropower impacts

Upper Columbia spring chinook runs are subject to passage mortalities associated with mainstem hydroelectric projects. Production from all of these drainages passes through the four lower river federal projects and a varying number of Mid-Columbia River Public Utility District projects. The Wenatchee River enters the Columbia River above seven mainstem dams, the Entiat above eight dams; the Methow River and Okanogan Rivers above nine dams. The draft Mid-Columbia Habitat Conservation Plan establishes salmonid survival objectives for Wells, Rocky Reach, and Rock Island dams. After 1998, Douglas PUD began operating Wells Dam in accordance with the draft HCP. Although some operational improvements were implemented throughout the 1990's, measures to fully implement the provisions of the draft HCP were not in place at all three projects until 2003. Interim operating guidelines designed to improve survival have been applied at Wanapum and Priest Rapids Dams. Operational improvements have been made to increase outmigrant survival through the lower Columbia mainstem hydroelectric dams (FCRPS Biological Opinion 2000).

Each of the upper Columbia River spring-run chinook salmon areas has a particular set of habitat problems. In general, tributary habitat problems affecting this ESU include the effects of increasing urbanization on the lower reaches, irrigation/flow diversions in up-river sections of the major drainage, and the impacts of grazing on middle reaches.

Previous assessments of stocks within this ESU have identified several as being at risk or of concern. WDF et al. (1993) considered nine stocks within this ESU, of which eight were considered to be of native origin and predominately natural production. The status of all nine stocks was considered as depressed.

Nehlsen et al. (1991) listed six additional stocks from the upper Columbia River as extinct. All of those stocks were associated with drainages entering the Columbia River main stem above Chief Joseph and Grand Coulee Dams. Those projects blocked off access by adult anadromous fish to the upper basin.

Table A.2.3.1. Summary of abundance and trend information for Upper Columbia River spring-run chinook salmon relative to previous BRT status review. Five-year geometric means calculated using years 1997 to 2001 unless otherwise noted. Interim targets from Ford et al. (2001). Previous years 1987-1996.

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Methow Total *	41	680 (79 – 9,904)	282	144	+2.0	-15.3	2,000	34%
Methow R. Main stem *	41	161 Redds (17 –2,864)			+6.5			
Twisp R. *	46	58 Redds (10 – 369)		87	-9.8	-27.4		
Chewuch R. *	59	58 Redds (6 – 1105)		62	-2.9	-28.1		
Lost/Early Winters Cr. *	46	12 (3 – 164)	6	62**	-14.1	-23.2**		
Entiat R.	58	111 (53 – 444)	65	89	-1.2	-19.4	500	22%
Wenatchee Total	58	470 (119 – 4,446)	274	27	-1.5	-37.4	3,750	13%
Chiwawa R.	53	109 Redds (34 – 1,046)		134	-0.7	-29.3		
Nason Cr.	61	54 Redds (8 – 374)		85	-1.5	-26.0		
Upper Wenatchee	34	8 Redds (0 – 215)			-8.9			
White R.	92	9 Redds (1 – 104)		25	-6.6	-35.9		
Little Wenatchee	79	11 Redds (3 – 74)		57	-25.8	-25.8		

* 5 year geometric mean calculated without year 1998; no data available
** Lost River Only

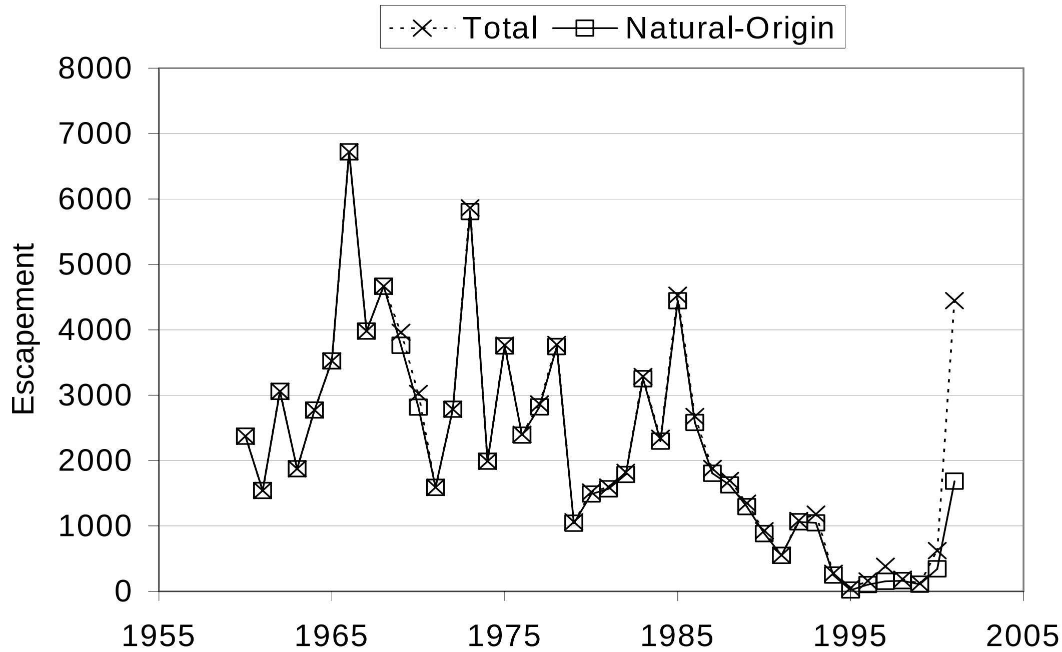


Figure A.2.3.1. Wenatchee spring-run chinook salmon spawning escapement; estimates expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Mosey & Murphy (2002).

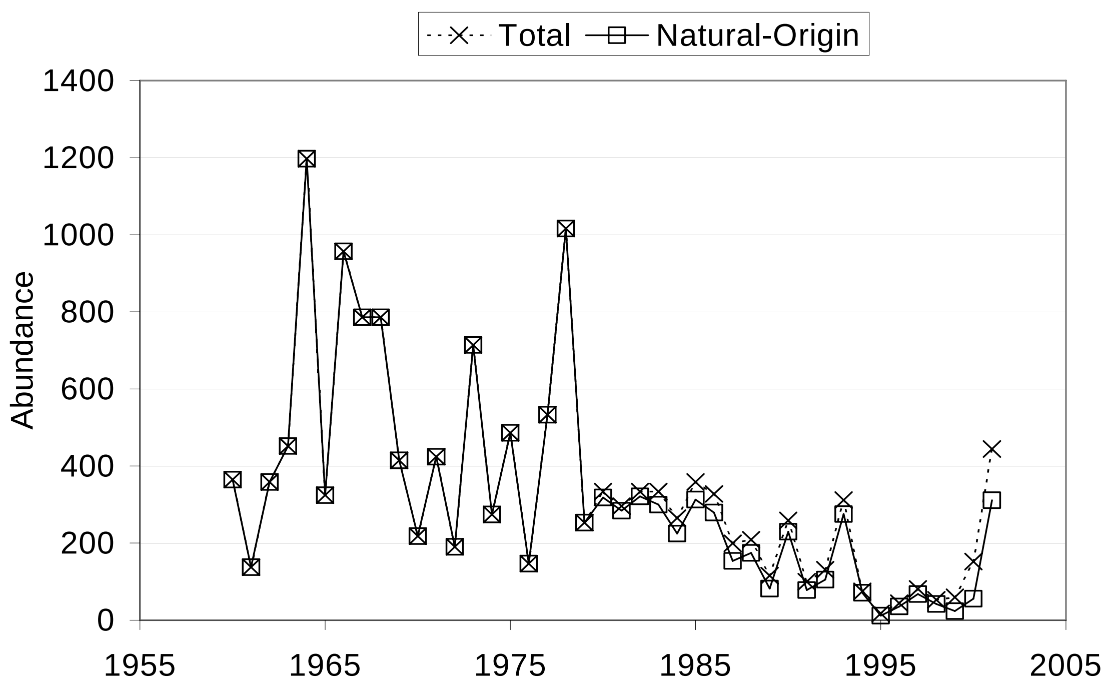


Figure A.2.3.2. Entiat spring-run chinook salmon spawning escapement; estimates from expanded redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent-year data from Carie (2002).

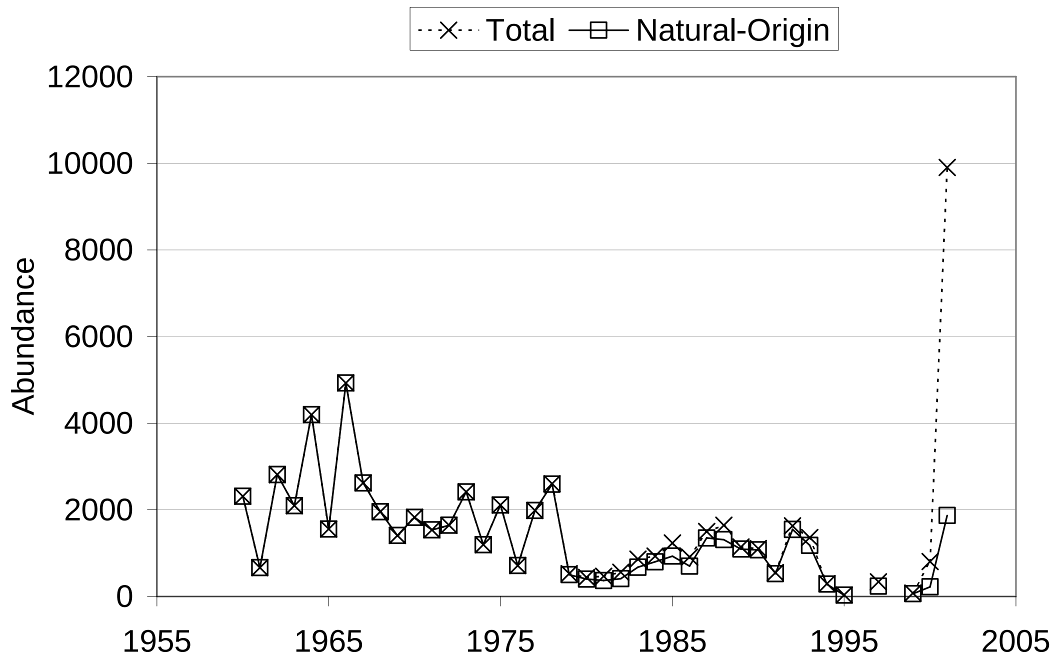


Figure A.2.3.3. Methow spring-run chinook salmon spawning escapement; estimates expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Yakima Indian Nation Fisheries (J. Hubbell, pers. comm.).

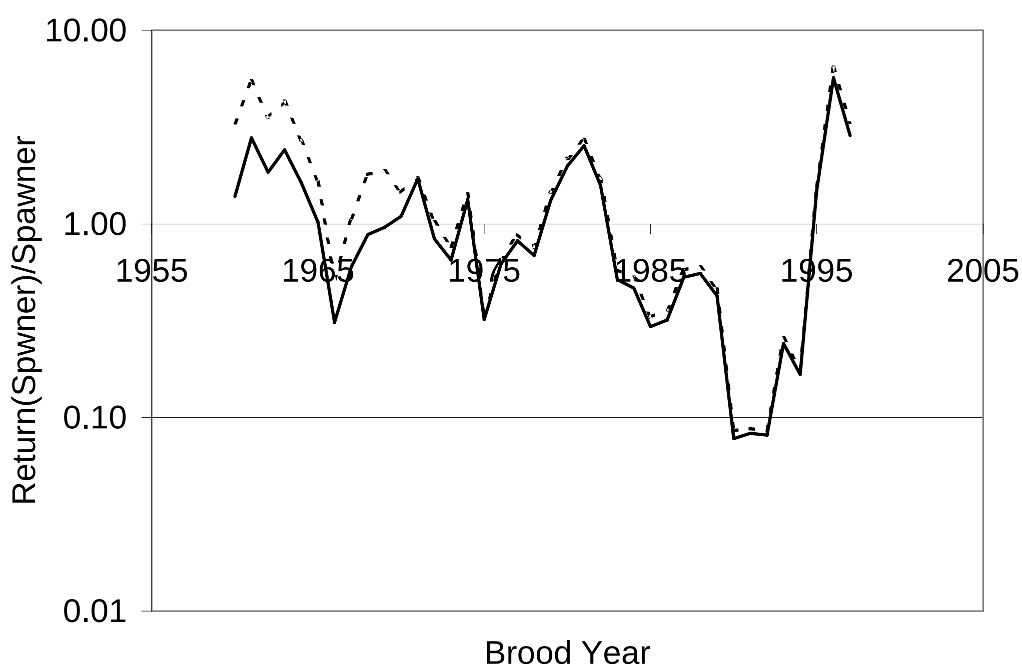


Figure A.2.3.4. Wenatchee spring-run chinook salmon returns/spawner by broodyear (returns to spawning grounds), calculated as estimated natural returns to the spawning grounds divided by brood year total spawners (solid line) and returns adjusted to recent average harvest rate (1985-2001; dashed line)

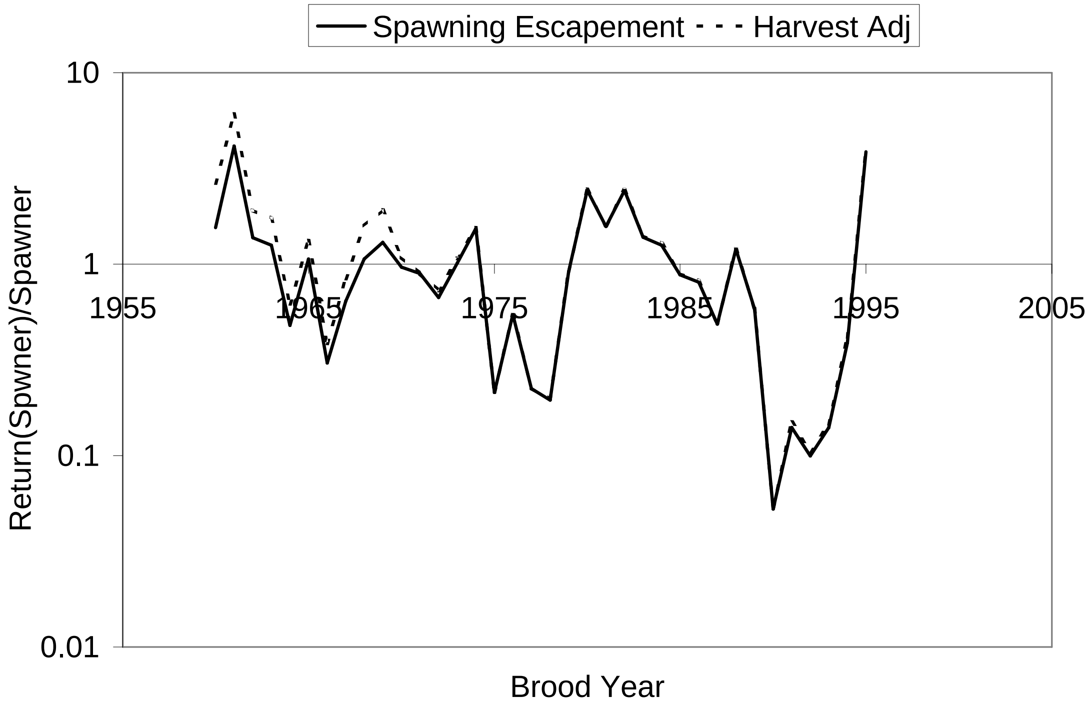


Figure A.2.3.5. Methow spring-run chinook salmon returns/spawner by brood year (returns to spawning grounds).

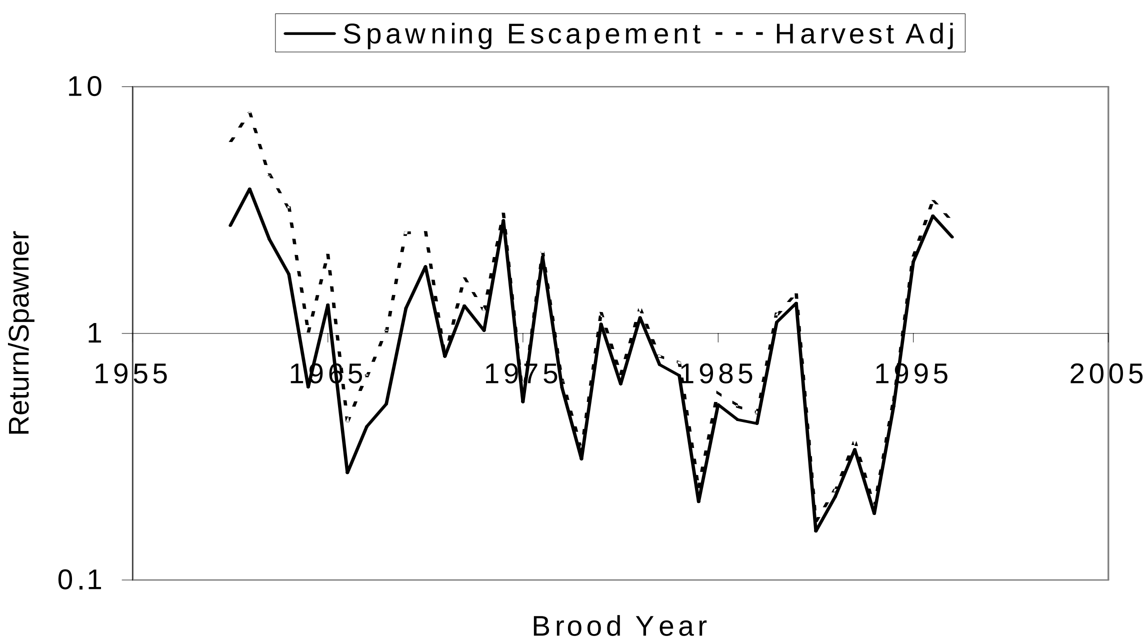


Figure A.2.3.6. Entiat spring-run chinook salmon returns/spawner by brood year (returns to spawning grounds).

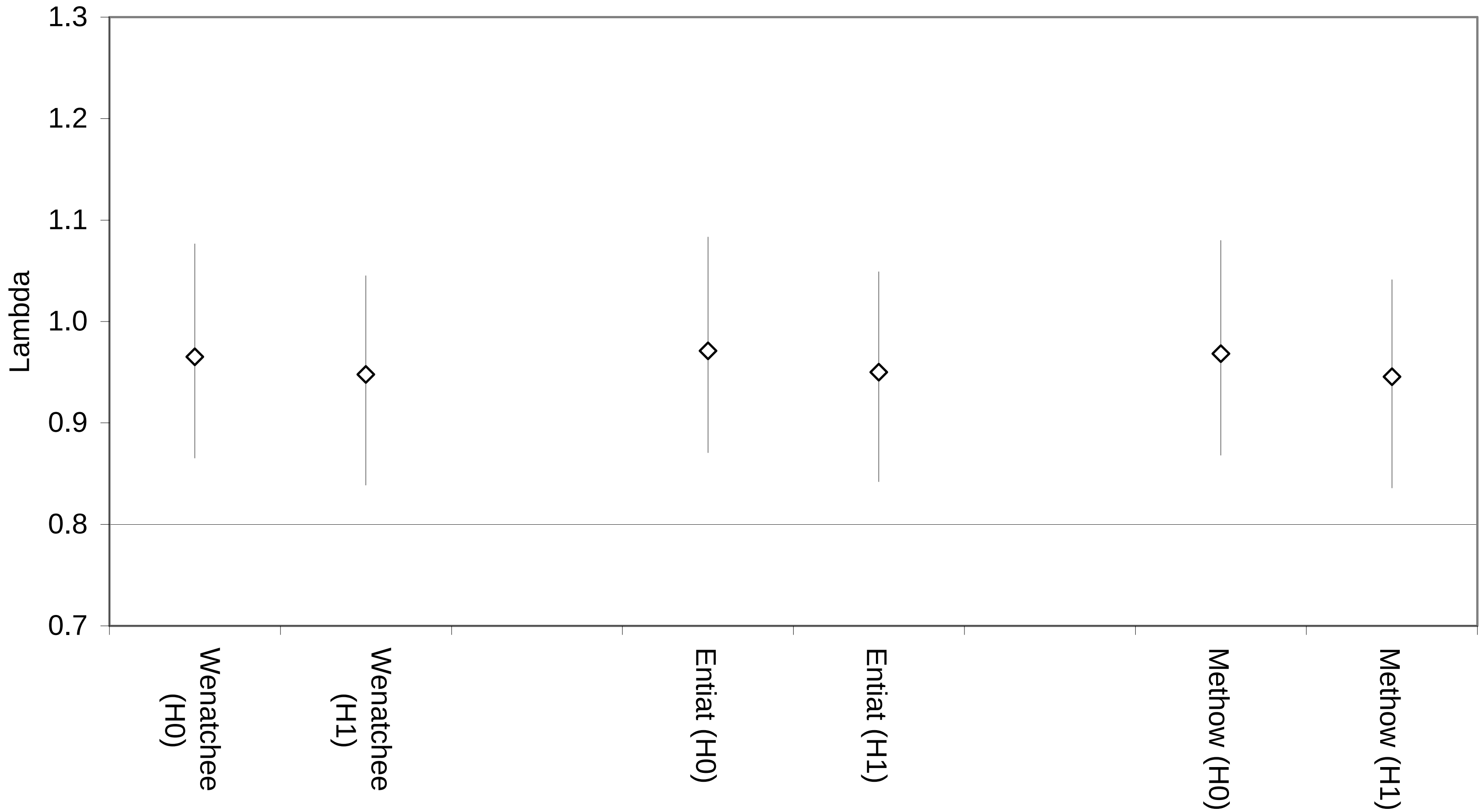


Figure A.2.3.7. Long-term annual growth rates (λ) for upper Columbia River spring chinook salmon populations. Error bars represent 95% confidence limits (H0 - hatchery fish are assumed to have zero reproductive success; H1 - hatchery –origin spawners are assumed to have the same reproductive success as natural-origin fish.).

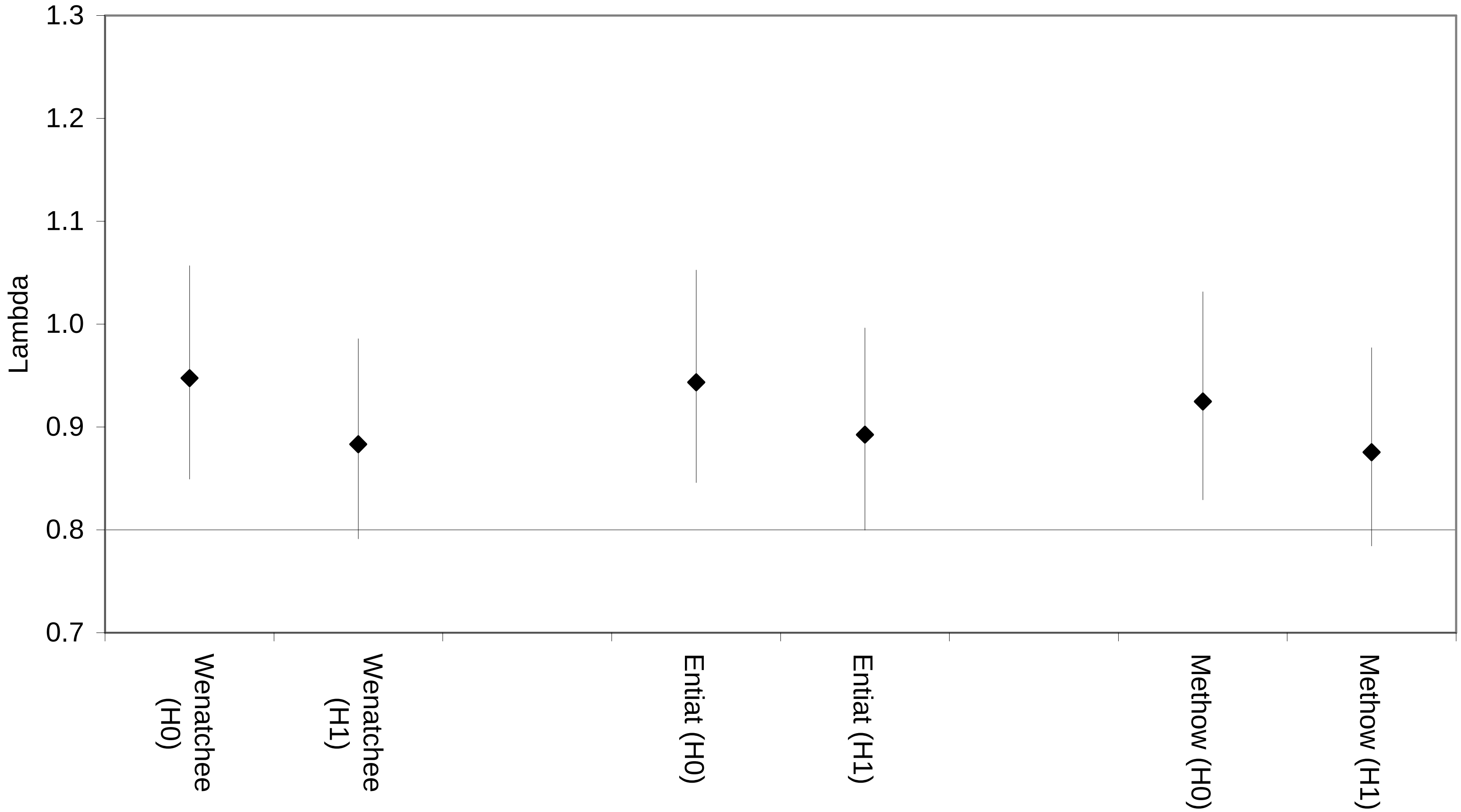


Figure A.2.3.8. Short-term (1990-2001) annual growth rates (λ) for upper Columbia River spring chinook salmon populations. Error bars represent 95% confidence limits of the trend (H0 - hatchery fish are assumed to have zero reproductive success; H1 – hatchery-origin spawners are assumed to have the same reproductive success as natural-origin fish).

A.2.4 PUGET SOUND CHINOOK SALMON

Primary contributors: Mary Ruckelshaus and Norma Jean Sands (Northwest Fisheries Science Center)

The status of Puget Sound chinook salmon was formally assessed during a coastwide status review (Myers et al. 1998). In November 1998, a BRT was convened to update the status of this ESU by summarizing information received since that review and comments on the 1997 status review (NMFS 1998). The following section ("*Summary of Previous BRT Conclusions*") summarizes the findings and conclusions made at the time of the 1998 status review update; the section after that *("Summary of New Information*") reports on new information received through March, 2003 and the conclusions of the 2003 BRT based on the new information.

A.2.4.1. Summary of Previous BRT conclusions

Status and trends

The BRT concluded in 1998 that the Puget Sound chinook ESU was likely to become endangered in the foreseeable future. The estimated total run size of chinook salmon to Puget Sound in the early 1990s was 240,000 chinook, down from an estimated 690,000 historical run size. The 5-year geometric mean of spawning escapement of natural chinook salmon runs in North Puget Sound during the period from 1992-1996 was approximately 13,000. Both long- and short-term trends for these runs were negative, with few exceptions. In south Puget Sound, spawning escapement of the natural runs averaged 11,000 spawners at the time of the last status review update. In this area, both long- and short-term trends were predominantly positive. In Hood Canal, spawning populations in six streams were considered a single stock by the co-managers because of extensive transfers of hatchery fish (WDF et al. 1993). Fisheries in the area were managed primarily for hatchery production and secondarily for natural escapement; high harvest rates directed at hatchery stocks resulted in failure to meet natural escapement goals in most years (USFWS 1997a). The 5-year geometric mean natural spawning escapement at the time of the last update was 1,100, with negative short- and long-term trends (except in the Dosewallips River). The ESU also includes the Dungeness and Elwha Rivers, which have natural chinook salmon runs as well as hatcheries. The Dungeness River had a run of spring/summer-run chinook salmon with a 5-year geometric mean natural escapement of 105 fish at the time of the last status review update. The Elwha River has a 5-year geometric mean escapement of 1,800 fish during the mid-1990s, which includes a large, but unknown fraction of naturally spawning hatchery fish. Both the Elwha and Dungeness populations exhibited downward trends in abundance in the 1990s.

Threats

Habitat throughout the ESU has been blocked or degraded. In general, upper tributaries have been impacted by forest practices and lower tributaries and mainstem rivers have been impacted by agriculture and/or urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of critical habitat issues for streams in the range of this ESU, including changes in flow regime (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish Rivers), streambed instability (most basins), estuarine loss (most basins), loss of large woody debris (Elwha, Snohomish, and White Rivers), loss of pool habitat (Nooksack, Snohomish, and Stillaguamish Rivers), and blockage or passage problems associated with dams or other structures (Cedar, Elwha, Green/Duwamish, Snohomish, and White Rivers). The Puget Sound Salmon Stock Review Group (PFMC 1997a) provided an extensive review of habitat conditions for several of the stocks in this ESU. It concluded that reductions in habitat capacity and quality have contributed to escapement problems for Puget Sound chinook salmon, citing evidence of direct losses of tributary and mainstem habitat due to dams, and of slough and side-channel habitat due to diking, dredging, and hydromodification. It also cited reductions in habitat quality due to land management activities.

WDF et al. (1993) classified 11 out of 29 stocks in this ESU as being sustained, in part, through artificial propagation. Nearly 2 billion fish have been released into Puget Sound tributaries since the 1950s (Myers et al. 1998). The vast majority of these have been derived from local returning fall-run adults. Returns to hatcheries have accounted for 57% of the total spawning escapement, although the hatchery contribution to spawner escapement is probably much higher than that, due to hatchery-derived strays on the spawning grounds. Almost all of the releases into this ESU have come from stocks within this ESU, with the majority of within ESU transfers coming from the Green River Hatchery or hatchery broodstocks that have been derived from Green River stock (Marshall et al. 1995). The electrophoretic similarity between Green River fall-run chinook salmon and several other fall-run stocks in Puget Sound (Marshall et al. 1995) suggests that there may have been a significant effect from some hatchery transplants. Overall, the pervasive use of Green River stock throughout much of the extensive hatchery network that exists in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Harvest impacts on Puget Sound chinook salmon stocks were quite high. Ocean exploitation rates on natural stocks averaged 56%-59%; total exploitation rates averaged 68%-83% (1982-89 broodyears) (PSC 1994). Total exploitation rates on some stocks have exceeded 90% (PSC 1994).

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern (reviewed in Myers et al. 1998).

A.2.4.2 New Data and Updated Analyses

ESU status at a glance

Historical peak run size	~690,000
Historical populations	31

Extant populations	22
5-year geometric mean natural spawners per population	222 – 9,489 (median = 766)
Long-term trend per population	0.92 – 1.2 (median = 1.0)
Recent λ (H1) per population	0.67 – 1.2 (median = 1.0)

Listing status Threatened

ESU structure

The Puget Sound ESU is comprised of 31 historically quasi-independent populations of chinook, 22 of which are believed to be extant currently (Puget Sound TRT 2001 and 2002). The populations that are presumed to be extinct are mostly of early-returning fish, and most of these are in the mid- to southern parts of the Puget Sound or in Hood Canal/Strait of Juan de Fuca (Table A.2.4.1). The populations in the ESU with the greatest estimated fractions of hatchery fish tend to be in the mid- to southern parts of Puget Sound, in Hood Canal, and in the Strait of Juan de Fuca (Table A.2.4.2).

Table A.2.4.1. Historical populations of chinook salmon in the Puget Sound ESU (PSTRT 2001). Run-timing types for each population and the biogeographic region within which each population occurs also are noted (Puget Sound TRT 2001 and 2002).

Population	Status	Run-Timing	Bio-Geographic Region	Reference
N. Fork Nooksack	Extant	early	Strait of Georgia	
S. Fork Nooksack	Extant	early	Strait of Georgia	
Nooksack late	**Extinct**	late	Strait of Georgia	1
Lower Skagit	Extant	late	Whidbey Basin	
Upper Skagit	Extant	late	Whidbey Basin	
Lower Sauk	Extant	late	Whidbey Basin	
Upper Sauk	Extant	early	Whidbey Basin	
Suiattle	Extant	early	Whidbey Basin	
Upper Cascade	Extant	early	Whidbey Basin	
N. Fork Stillaguamish	Extant	late	Whidbey Basin	
S. Fork Stillaguamish	Extant	late	Whidbey Basin	
Stillaguamish early	**Extinct**	early	Whidbey Basin	2,3
Skykomish	Extant	late	Whidbey Basin	
Snoqualmie	Extant	late	Whidbey Basin	
Snohomish early	**Extinct**	early	Whidbey Basin	2,3
Cedar	Extant	late	Main Basin/ South Basin	
N. Lake Washington	Extant	late	Main Basin/ South Basin	
Green/Duwamish	Extant	late	Main Basin/ South Basin	
Green/Duwamish early	**Extinct**	early	Main Basin/ South Basin	2,3
Puyallup	Extant	late	Main Basin/ South Basin	
White	Extant	early	Main Basin/ South Basin	
Puyallup early	**Extinct**	early	Main Basin/ South Basin	2
Nisqually	Extant	late	Main Basin/ South Basin	
Nisqually early	**Extinct**	early	Main Basin/ South Basin	2,4
Skokomish	Extant	late	Hood Canal	
Skokomish early	**Extinct**	early	Hood Canal	2,3,5
Dosewallips	Extant	late	Hood Canal	
Dosewallips early	**Extinct**	early	Hood Canal	2,4
Dungeness	Extant	late	Strait of Juan de Fuca	
Elwha	Extant	late	Strait of Juan de Fuca	
Elwha early	**Extinct**	early	Strait of Juan de Fuca	2,3

1=PS TRT 2001; 2= Nehlsen et al. 1991; 3= WDF et al. 1993; 4= ONRC 1995; 5= Deschamps 1954

New information obtained for the 22 populations of chinook salmon in the Puget Sound ESU is summarized in Appendix A.5.2. Sources of data and detailed information on data years are provided for each population separately in the Appendix.

Abundance of natural spawners

The most recent 5-year (1998-2002) geometric mean of natural spawners in populations of Puget Sound chinook salmon ranges from 222 (in the Dungeness) to almost 9,500 fish (in the upper Skagit population). Most populations contain natural spawners numbering in the high hundreds (median recent natural escapement = 766); of the ten populations with greater than 1,000 natural spawners, only two are thought to have a low fraction of hatchery fish (Table A.2.4.2; Figure A.2.4.1). Estimates of the fraction of natural spawners that are of hatchery origin are sparse—data are available for only twelve of the 22 populations in the ESU, and such information is available for only the most recent 5-10 years (Table A.2.4.2). Estimates of the hatchery fraction of natural spawners come from counts of otolith-marked local hatchery fish sampled from carcasses (Nooksack River Basin, Snohomish River Basin), adipose fin clip counts from redd count surveys (Skagit River Basin), and coded-wire tag sampling (NF Stillaguamish and Green River). In general, populations in the Skagit river basin are the only ones with presumed low estimates of naturally spawning hatchery fish. The Stillaguamish and Snohomish populations have moderate estimates of naturally spawning hatchery fish. Estimates of historical equilibrium abundance from predicted pre-European settlement habitat conditions range from 1,700 to 51,000 potential chinook salmon spawners per population (Mobrand 2000). The historical estimates of equilibrium abundance are several orders of magnitude higher than realized spawner abundances currently observed throughout the ESU.

Table A.2.4.2. Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

Population	**Geometric mean natural spawners (1998-2002)**	**Arithmetic mean natural spawners (1998-2002) (min, max)**	**Geometric mean natural-origin spawners (1998-2002)**	**Average% hatchery fish in escapement[5] 1997-2001 (min, max since 1992)**	**Chinook salmon hatcheries in basin?**	**Hatchery fraction data? (years)**	**EDT estimate of historical abundance[3]**
NF Nooksack[1]	1,538	2,275 (366-4,671)	125	91 (88 –95)	Kendall (NF; rm 45)	Yes (1995-2002)	26,000
SF Nooksack[1]	338	372 (157-620)	197	40 (24 - 55)	Kendall (NF; rm 45)	Yes (1999-2002)	13,000
Lower Skagit	2,527	2,833 (1,043-4,866)	2,519	0.2 (0 – 0.7)	Marblemount (mouth of Cascade)[a]	Yes (1998-2001)	22,000
Upper Skagit	9,489	10,468 (3,586-13,815)	9,281	2 (2 – 3)	Marblemount (mouth of Cascade)[a]	Yes (1995-2000)	35,000
Upper Cascade	274	329 (83-625)	274	0.3	Marblemount (mouth of Cascade)[a]	No (assume low)	1,700
Lower Sauk	601	669 (295-1,103)	601	0	Marblemount (mouth of Cascade)[a]	Yes (2001)	7,800
Upper Sauk	324	349 (180-543)	324	0	Marblemount (mouth of Cascade)[a]	No (assumed)	4,200
Suiattle	365	399 (208-688)	365	0	Marblemount (mouth of Cascade)[a]	No (assumed)	830
NF Stillaguamish	1,154	1,172 (845-1,403)	671	40 (13 – 52)	Tribal (NF)	Yes (1988-1999)	24,000

SF Stillaguamish	270	272 (243-335)	NA	NA	Tribal (NF)	none	20,000
Skykomish	4,262	4,286 (3,455-4,665)	2,392	40 (11 - 66)	Wallace R.	Yes (1979-2001)	51,000
Snoqualmie	2,067	2,229 (1,344-3,589)	1,700	16 (5 – 72)	Wallace R.	Yes (1979-2001)	33,000
NL Washington	331	351 (227-537)	NA	NA	Lake Wash, Issaquah, UW	none	NA
Cedar	327	394 (120-810)	NA	NA	Lake Wash, Issaquah, UW	none	NA
Green	8,884	9,286 (6,170-13,950)	1,099	83 (35 -100)	Soos, Icy and Keta Cr.	Yes (1989-1997)	NA
White[2]	844	1,039 (316-2,002)	NA	NA	White R (rm 23); Voights Cr. (Carbon R), Diru (rm 5)	none	NA
Puyallup	1,653	1,679 (1,193-1,988)	NA	NA	Voights Cr. (Carbon R), Diru (rm 5)	none	33,000
Nisqually	1,195	1,221 (834-1,542)	NA	NA	Kalama, Clear Cr	none	18,000
Skokomish	1,392	1,437 (926-1,913)	NA	NA	George Adams (Purdy Cr., lower Skok)	none	NA
Dosewallips[4]	*48*	*50 (29-65)*	*NA*	*NA*	*none*	*none*	*4,700*

Duckabush[4]	*43*	*57 (20-151)*	*NA*	*NA*	*none*	*none*	*NA*
Hamma Hamma[4]	*196*	*278 (32-557)*	*NA*	*NA*	*none*	*none*	*NA*
Mid Hood Canal	311	381 (95-762)	NA	NA	none	none	NA
Dungeness[2]	222	304 (75-663)	NA	NA	Dungeness (and Hurd Cr)	none	8,100
Elwha[*6]	688	691 (633-813)	NA	NA	Tribal (rm 1) and State (rm 3.2)	none	NA

[*]2002 natural escapement data not available

[1]NF Nooksack natural escapement counts include estimated numbers of spawners from the MF Nooksack since the late 1990s and chinook salmon returning to the NF hatchery that were released back into the NF to spawn; SF Nooksack natural escapement estimates contain naturally spawning hatchery fish from the "early" and "late" run hatchery programs in the Nooksack River Basin.

[a]Previous summer-run chinook salmon hatchery program discontinued--last returns in 1996; current summer-run program (initiated in 1994) collects hatchery broodstock from spawners in upper Skagit River.

[2]Captive broodstock program for "early" run chinook salmon ended in 2000; estimates of natural spawning escapement include an unknown fraction of naturally spawning hatchery-origin fish from "late" and "early" run hatchery programs in the White and Puyallup river basins.

[3] Estimates of historical equilibrium abundance based on an EDT analysis conducted by the co-managers in Puget Sound (PSTRT 2002).

[4] The Puget Sound TRT considers chinook salmon spawning in the Dosewallips, Duckabush and Hamma Hamma rivers to be sub-populations of the same historically independent population; annual counts in those 3 streams are variable due to inconsistent visibility during spawning ground surveys.

[5]Estimates of the fraction of hatchery fish in natural spawning escapements are from the Puget Sound TRT database; Green River estimates are from Marianna Alexandersdottir, NWIFC, unpublished data.

[6]Estimates of natural escapement do not include volitional returns to the hatchery or those fish gaffed or seined from spawning grounds for broodstock collection

Trends in natural spawners

Long-term trends in abundance for naturally spawning populations of chinook salmon in Puget Sound indicate that approximately half of the populations are declining and half are increasing in abundance over the length of available time series (Table A.2.4.3; Figure A.2.4.1). The median over all populations of long-term trend in abundance is 1.0 (range 0.92 – 1.2), indicating that most populations are just replacing themselves. The most extreme declines in natural spawning abundance have occurred in the combined Dosewallips and Elwha populations over the long term. Those populations with the greatest long-term population growth rates are the North Fork Nooksack and the White. All of the populations reported above are likely to have a moderate-high fraction of naturally spawning hatchery fish, so it is not possible to say what the trends in naturally spawning, natural-origin chinook salmon might be in those populations.

Fewer populations exhibit declining trends in abundance over the short term than over the long term—4 of 22 populations in the ESU are declining from 1990-2002 (median = 1.06, range = 0.96-1.4) (Table A.2.4.3). In contrast, estimates of short-term population growth rates suggest a very different picture when the reproductive success of hatchery fish is assumed to be 1. As discussed in the *Methods* section, short-term population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally spawning hatchery fish: the reproductive success was 0 (H0), or the reproductive success was equivalent to that of natural-origin fish (H1). Short-term λ estimates assuming the reproductive success of hatchery fish was 0 are very similar to estimates of short-term trend, so they are not reported here. The median short-term λ over all populations (when the reproductive success of hatchery fish is assumed to be 1) is λ–H1 = 1.0 (range = 0.67-1.2).

The median estimate of short-term population growth would be even lower if the estimates of the fraction of naturally spawning hatchery fish were available for all populations in the ESU. As mentioned earlier, the 10 populations in the ESU for which no hatchery fraction information is available are all suspected to have a moderate-to-high fraction of hatchery-origin adults in natural escapements. In those cases where hatchery information is available and the fraction of hatchery-origin natural spawners is significant (e.g., North Fork Nooksack, Green River), the effect of the reproductive success of hatchery fish assumption on estimates of λ is dramatic. The most extreme short-term declines in natural spawner abundance have occurred in the Upper Sauk, Cedar, Puyallup, and Elwha populations. Of these populations, only the Upper Sauk is likely to have a low fraction of hatchery fish in escapements. When λ is calculated assuming the reproductive success of hatchery fish is equivalent to that of natural-origin fish, the biggest estimated short-term population declines are in the Green, Skykomish, North Fork Stillaguamish and North Fork Nooksack populations (Table A.2.4.3). Again, if hatchery fraction data were available for the additional 10 populations in the ESU for which such data are missing, more examples of significant short-term declines in population growth rate surely would emerge. The populations with the most positive short-term trends and population growth rates are the combined Dosewallips and White River populations. Both of these populations are thought to have a moderate fraction of naturally spawning hatchery fish, but since such estimates are not available, estimating the trends in natural-origin spawners is not possible.

Another indicator of the productivity of chinook salmon populations is presented in the time series figure showing the total number of spawners (natural and hatchery origin) and the number of preharvest recruits produced by those spawners against time (Figure A.2.4.2). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner. Generating this type of figure requires harvest and age structure information and therefore could be produced for only a limited number of years in some populations. Representing information this way can indicate if there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest. In most populations, the preharvest recruits exceeded spanwers in all but a few years for which data are available (Figure A.2.4.2).

Table A.2.4.3. Estimates of long- and short-term trends and the short-term median population growth rate (λ), and their 95% confidence intervals for spawners in Puget Sound chinook salmon populations (data are from the Puget Sound TRT, unpublished data). Long and short-term trends are calculated on all spawners; short-term λ is calculated assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for those populations where information on the fraction of hatchery fish in natural spawning abundance is available).

Population	**Data years**	**LT Trend (CI)**	**ST Trend (CI) (1990-2002)**	**ST λ ($\pm$ lnSE) (1990-2002)**
N. Fork Nooksack	1984-2001	1.16 (1.04-1.30)	1.42 (1.18-1.70)	0.75 (0.07)
S. Fork Nooksack	1984-2001	1.00 (0.96-1.05)	1.07 (0.98-1.15)	0.94 (0.05)
Lower Skagit	1952-2002	0.99 (0.97-1.00)	1.06 (0.94-1.18)	1.05 (0.09)
Upper Skagit	1952-2002	1.00 (0.99-1.01)	1.06 (0.98-1.14)	1.05 (0.06)
Upper Cascade	1984-2002	1.04 (1.00-1.08)	1.05 (0.98-1.14)	1.06 (0.05)
Lower Sauk	1952-2002	0.99 (0.98-1.00)	1.03 (0.91-1.17)	1.01 (0.12)
Upper Sauk	1952-2002	0.97 (0.96-0.99)	0.97 (0.89-1.06)	0.96 (0.06)
Suiattle	1952-2002	0.99 (0.98-0.99)	1.00 (0.92-1.08)	0.99 (0.06)
N. Fork Stillaguamish	1974-2002	1.01 (0.99-1.03)	1.06 (1.01-1.11)	0.92 (0.04)
S. Fork Stillaguamish[1]	1974-2002	1.02 (1.00-1.04)	1.00 (0.97-1.02)	0.99 (0.02)
Skykomish	1965-2002	0.99 (0.98-1.00)	1.07 (1.03-1.11)	0.87 (0.03)
Snoqualmie	1965-2002	1.03 (1.01-1.04)	1.10 (1.01-1.21)	1.00 (0.04)
N. Lake Washington[1]	1983-2002	0.97 (0.91-1.03)	1.04 (0.91-1.19)	1.07 (0.07)
Cedar[1]	1965-2002	0.97 (0.95-0.98)	0.97 (0.89-1.07)	0.99 (0.07)
Green[1]	1968-2002	1.02 (1.01-1.04)	1.05 (0.98-1.13)	0.67 (0.06)

White[1]	1970-2002	1.05 (1.00-1.10)	1.14 (1.06-1.22)	1.16 (0.06)
Puyallup[1]	1968-2002	1.02 (1.00-1.04)	0.96 (0.91-1.02)	0.95 (0.06)
Nisqually[1]	1968-2002	1.02 (0.99-1.05)	1.06 (0.93-1.20)	1.04 (0.07)
Skokomish[1]	1987-2002	0.99 (0.93-1.05)	1.04 (0.97-1.12)	1.04 (0.04)
Combined Dosewallips[1]	1968-2002	0.96 (0.93-0.98)	1.11 (0.99-1.20)	1.17 (0.10)
Dungeness[1]	1986-2002	1.02 (0.94-1.10)	1.07 (0.94-1.20)	1.09 (0.11)
Elwha[1]	1986-2001	0.92 (0.84-1.00)	0.97 (0.86-1.10)	0.95 (0.11)

[1]Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.

Updated threats information

The Puget Sound TRT (unpublished data) has estimated adult equivalent exploitation rates for each population of chinook salmon in the ESU (Table A.2.4.4). Exploitation rates are the proportion of the returning population that are caught in fisheries or are killed as a result of fishing activities (e.g., non-retention mortality). These harvest estimates include mortality from sport and commercial fisheries in the ocean, Puget Sound, and in rivers. Exploitation rate estimates are a function of coded-wire tag (i.e., CWT) recoveries, escapement estimates, and estimates of incidental mortalities provided by the Chinook Technical Committee (CTC 2001). These harvest rates are equivalent to exploitation rates provdied by the CTC, but they are different from exploitation rates estimated by the FRAM model.

Exploitation rates on Puget Sound chinook salmon populations averaged 75% (median = 85%; range 31-92%) in the earliest 5 years of data availability and have dropped to an average of 44% (median = 45; range 26-63%) in the most recent 5-year period.

Table A.2.4.4. Estimated brood-year adult-equivalent exploitation rates on populations of Puget Sound chinook salmon (Puget Sound TRT unpublished data).

Population	**Data years (brood year)**	**Earliest 5-year mean exploitation rate (%)**	**Most recent 5-year mean exploitation rate (%)**
N. Fork Nooksack	1982 - 1998	43	26
S. Fork Nooksack	1982 - 1998	44	26
Lower Skagit[1]	1969 - 1998	86	61
Upper Skagit[1]	1969 - 1998	88	63
Upper Cascade[1]	1982 - 1998	80	56
Lower Sauk[1]	1969 - 1998	88	63
Upper Sauk[1]	*1979 - 1998*	*72*	*56*
Suiattle[1]	1979 - 1998	73	58
N. Fork Stillaguamish	1972 - 1998	89	40
S. Fork Stillaguamish	1972 - 1998	89	40

Skykomish	1969 - 1998	86	49
Snoqualmie	1969 - 1998	85	45
N. Lake Washington	1981 - 1998	40	27
Cedar	1969 - 1998	52	31
Green	1969 - 1998	82	57
White	1972 - 1998	90	26
Puyallup	1971 - 1998	53	30
Nisqually	1977 - 1998	92	62
Skokomish	1985 - 1998	90	31
Dosewallips	1985 - 1998	92	38
Dungeness	1984 - 1998	31	32
Elwha	1984 - 1998	64	44

[1]The population-specific harvest rates for the Skagit River Basin are in dispute; Puget Sound TRT, NOAA Fisheries Northwest Regional Office, and the Puget Sound co-managers are working to resolve different estimates resulting from the Pacific Salmon Commission (Chinook Technical Committee) and the FRAM model.

The Puget Sound TRT (unpublished data) has amassed estimates of the total number of hatchery-origin chinook salmon returning to streams (Table A.2.4.5). These estimates for each population include the total return—returns to natural spawning grounds and to hatchery racks within a population's geographic boundaries. These estimates do not account for possible strays of hatchery fish from outside the population's boundaries. It is apparent from Table A.2.4.5 that even populations of chinook salmon in northern Puget Sound (not a hatchery production management area for co-managers) receive significant numbers of adult hatchery fish returning each year. The numbers of hatchery-origin juvenile chinook salmon released into Puget Sound streams each year also are reported in Table A.2.4.5. Average annual numbers of juvenile releases have declined since the time of the last Status Review (1990-1994 vs. 1995-2001) in the Nooksack, Skagit and Green river basins, and releases have remained roughly the same in the north Lake Washington/Cedar, White/Puyallup and in south Puget Sound streams. In contrast, juvenile chinook salmon releases have increased in the Snohomish and Elwha river basins, in eastern Kitsap streams, and in Hood Canal. With the exception of the Skagit and Stillaguamish river basins, all major watersheds in Puget Sound receive annual releases of over a million (close to 7 million in Hood Canal) juvenile chinook salmon. Hatchery stocks of chinook salmon in Puget Sound have been categorized (SSHAG 2003) and are provided in Appendix A.5.1.

Table A.2.4.5. Total estimated recent annual average returns of hatchery-produced chinook salmon (adults returning to hatchery racks and to spawning grounds) and total releases of juvenile chinook salmon in streams containing independent populations of chinook salmon in Puget Sound (Puget Sound TRT and B. Waknitz, unpublished data).

<table>
<tr><th>Population</th><th>Average annual return to stream 1987–2001 (min-max)[1]</th><th colspan="2">Previous (1990-1994) average annual releases of chinook salmon hatchery juveniles by life-stage (in thousands)</th><th>Most recent (1995-2001) average annual releases of chinook salmon hatchery juveniles by life-stage (in thousands)</th></tr>
<tr><td>N. Fork Nooksack</td><td>1,720 (0 – 9,179)</td><td colspan="2" rowspan="2">5,500 (4,763 fall; 737 spring/summer)</td><td rowspan="2">3,081 fall</td></tr>
<tr><td>S. Fork Nooksack</td><td>1,254 (0 – 5,515)</td></tr>
<tr><td>Lower Skagit</td><td rowspan="6">1,171 (70 – 4,110)</td><td colspan="2" rowspan="6">2,251 (1,292 fall; 491 spring, 468 summer)</td><td rowspan="6">754 (32 fall; 423 spring; 299 summer)</td></tr>
<tr><td>Upper Skagit</td></tr>
<tr><td>Upper Cascade</td></tr>
<tr><td>Lower Sauk</td></tr>
<tr><td>Upper Sauk</td></tr>
<tr><td>Suiattle</td></tr>
<tr><td>N. Fork Stillaguamish</td><td>318 (2 – 777)</td><td colspan="2" rowspan="2">NA</td><td rowspan="2">178 summer</td></tr>
<tr><td>S. Fork Stillaguamish[2]</td><td>NA</td></tr>
<tr><td>Skykomish</td><td>3,666 (824 – 8,530)</td><td colspan="2" rowspan="2">1,926 (1,316 fall; 610 summer)</td><td rowspan="2">2,574 (1,401 fall; 1,173 summer)</td></tr>
<tr><td>Snoqualmie</td><td>2,921 (19 – 6,514)</td></tr>
<tr><td>N. Lake Washington[2]</td><td>NA</td><td colspan="2" rowspan="2">2,349 fall</td><td rowspan="2">2,077 fall</td></tr>
<tr><td>Cedar</td><td>NA</td></tr>
<tr><td>Green</td><td>13,565 (3,211 – 23,014)</td><td colspan="2">4,413 fall</td><td>3,681 fall</td></tr>
<tr><td>White[2]</td><td>NA</td><td rowspan="2">1,686 (1,672 fall, 14 spring)</td><td rowspan="3">70 fall in South Sound general</td><td rowspan="2">1,695 (1,669 fall; 26 spring)</td></tr>
<tr><td>Puyallup[2]</td><td>2,048 (762 – 3,484)</td></tr>
<tr><td>Nisqually[2]</td><td>2,559 (0 – 13,481)</td><td>NA</td><td>NA</td></tr>
<tr><td>Misc. south Puget Sound streams</td><td>NA</td><td colspan="2">6,947 fall</td><td>6,411 fall</td></tr>
<tr><td>Eastern Kitsap streams</td><td>NA</td><td colspan="2">2,851(2,519 fall; 332 spring)</td><td>3,771 (3,447 fall; 324 spring)</td></tr>
<tr><td>Skokomish[2]</td><td>3,621 (294 – 8,816)</td><td colspan="2" rowspan="2">4,928 (4,637 fall; 291 spring)</td><td rowspan="2">6,856 (6,793 fall; 63 spring)</td></tr>
<tr><td>Comb.Dosewallips[2]</td><td>NA</td></tr>
<tr><td>Dungeness[2]</td><td>NA</td><td colspan="2">NA</td><td>1,283 spring</td></tr>
<tr><td>Elwha</td><td>634 (97 – 2,089)</td><td colspan="2">1,831 fall</td><td>2,482 fall</td></tr>
</table>

[1]Hatchery rack-return data are not available for all streams.
[2]Estimates of hatchery-origin chinook salmon returning to spawn are not available.

A.2.4.3. Comparison with Previous Data

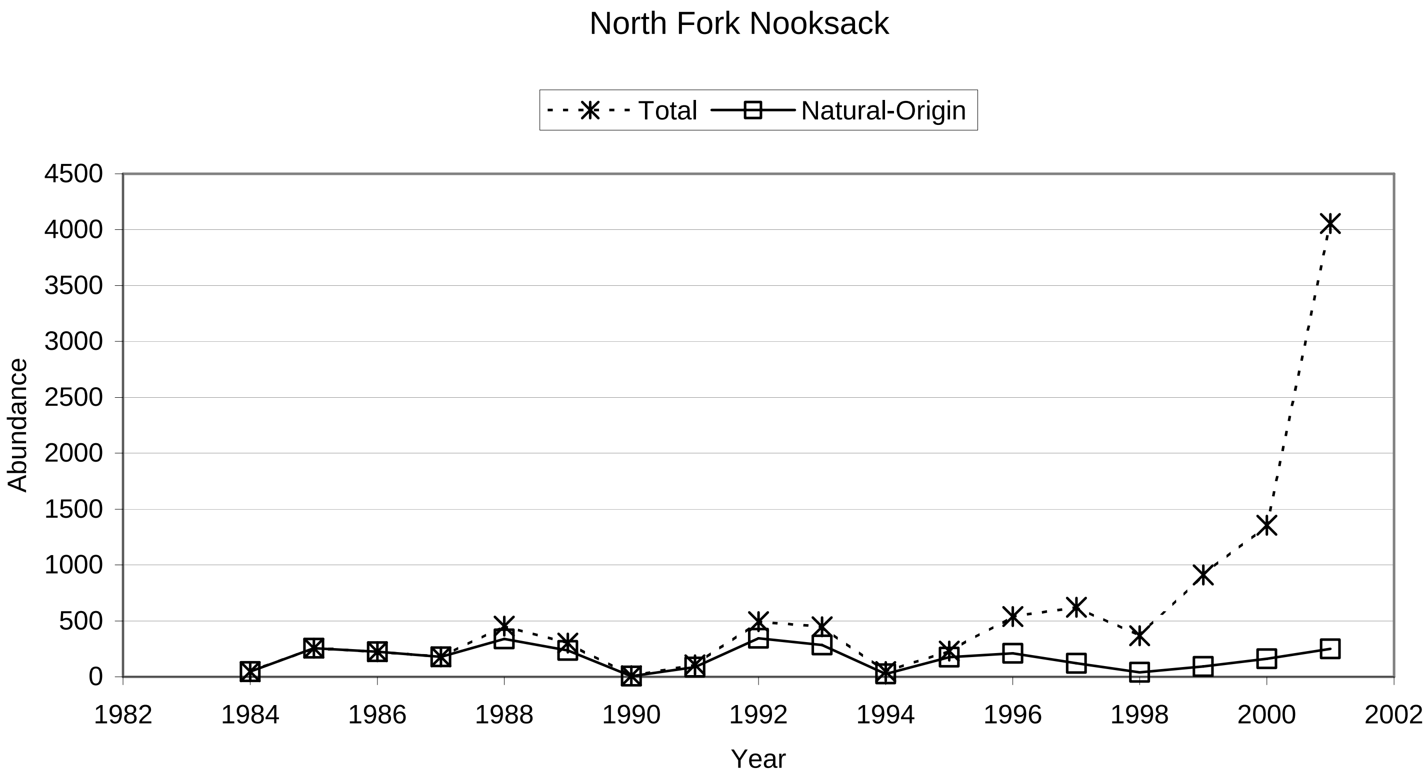
Overall, the natural spawning escapement estimates for Puget Sound chinook salmon populations are improved relative to those at the time of the previous status review of Puget Sound chinook salmon conducted with data through 1997. The differences between population escapement estimates between the previous status assessments using data from 1997 and the present assessment using data through 2002 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 5 years. The median across populations of the most recent 5-year geometric mean natural escapement for the same 22 populations through 1997 was N = 438 (compared to N = 771 through 2002), and the range was 1-5,400. As was the case at the time of the previous status review, it is not possible to determine the status of the natural-origin, natural spawners in half of the populations of chinook salmon in Puget Sound. The most dramatic change in recent natural escapement estimates from the previous status assessment was in the Green River—the recent natural-origin escapement estimate is lower than the previous one by almost 5,000 spawners. This apparent drop in natural escapement is probably due primarily to new information about the fraction of hatchery fish that are spawning naturally.

Throughout the ESU, the estimates of trends in natural spawning escapements for Puget Sound chinook salmon populations are similar to the previous status review of Puget Sound chinook salmon conducted with data through 1997. Some populations exhibit improvements in trends relative to the last status assessment, and others show more significant declines. As stated above for escapement estimates, the differences in trend estimates between the previous status assessments using data from 1997 and the present assessment using data through 2002 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 5 years. The median across populations of the long-term trend in natural spawners was a 1.1% decline per year through 1997, compared to a median estimate indicating a flat trend through 2002. Twelve populations had declining long-term trends through 1997, and 10 populations have declining long-term trends through 2002. Short-term trends are generally more positive in recent years—the median trend across 22 populations through 1997 was a 4% decline per year, and the median trend through 2002 was a 1.1% increase per year. Fourteen populations showed declining short-term trends at the time of the previous status reviews, and only four populations exhibit declining short-term trends in recent years. Nevertheless, as stated above for interpreting abundance estimates, we lack information on the fraction of naturally spawning, hatchery-origin fish for 10 of the 22 populations of chinook salmon in Puget Sound, so our understanding of the trend in natural-origin spawners among populations across the ESU is incomplete. An illustration of how misleading trend estimates on total natural spawners can be for estimating trends in natural-origin spawners can be found comparing the λ calculations assuming naturally spawning hatchery fish do (i.e., λ –H1) or do not (i.e., λ –H0) contribute naturally spawning offspring. For those 12 populations with information on the hatchery fraction of natural spawners in the ESU, 7 populations switched from an estimated positive short-term population growth rate to a negative one when hatchery fish were assumed to contribute naturally spawning offspring.

The spatial distribution of chinook salmon populations with a strong component of natural-origin spawners in the Puget Sound ESU has not changed since the time of the last status assessment. Populations containing significant numbers of natural-origin spawners whose status can be reliably estimated occur in the Skagit River Basin, the South Fork Stillaguamish, and the Snohomish River Basin. The remaining populations in mid- and south Puget Sound, Hood Canal and out the Strait of Juan de Fuca have significant (but non-quantifiable) fractions of hatchery-origin spawners, so their contribution to spatial structure in the ESU is not possible to estimate.

The change in diversity in the ESU from historical conditions also has not changed since the last status review. An estimated 31 independent populations of chinook salmon occurred historically in the ESU, and 22 remain extant. All but one of the 9 putatively extinct chinook salmon stocks is an early-run population (or component of a population). The loss of early-run chinook salmon stocks in Puget Sound represents an important loss of part of the evolutionary legacy of the historical ESU.

Figure A.2.4.1. Total and natural-origin spawner abundance estimates vs. year for populations of the Puget Sound chinook ESU.



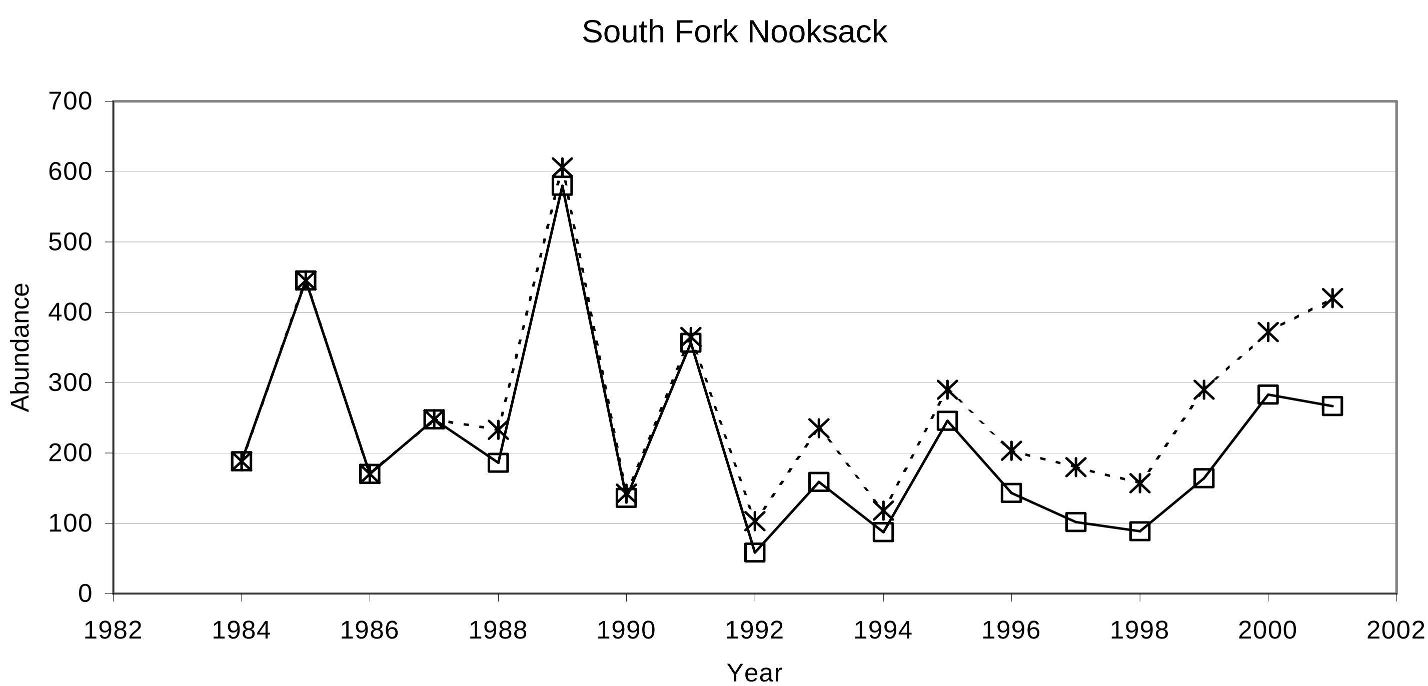
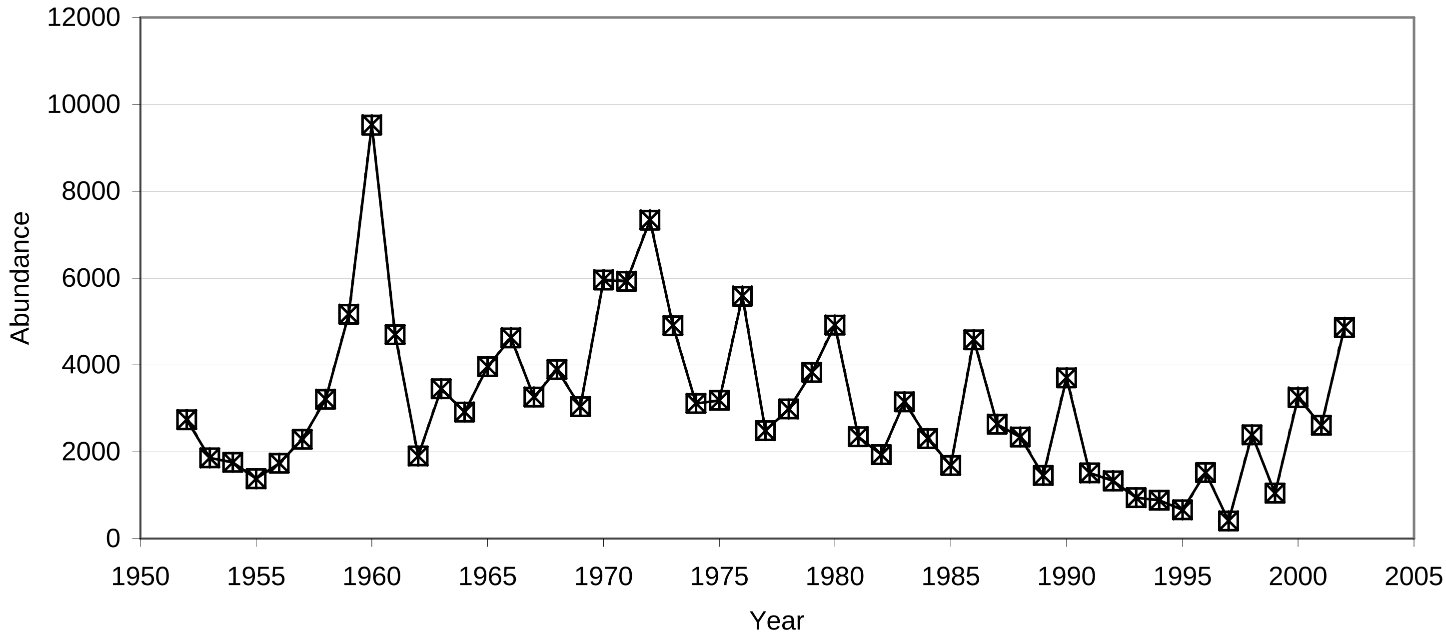


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)

Lower Skagit



Upper Skagit

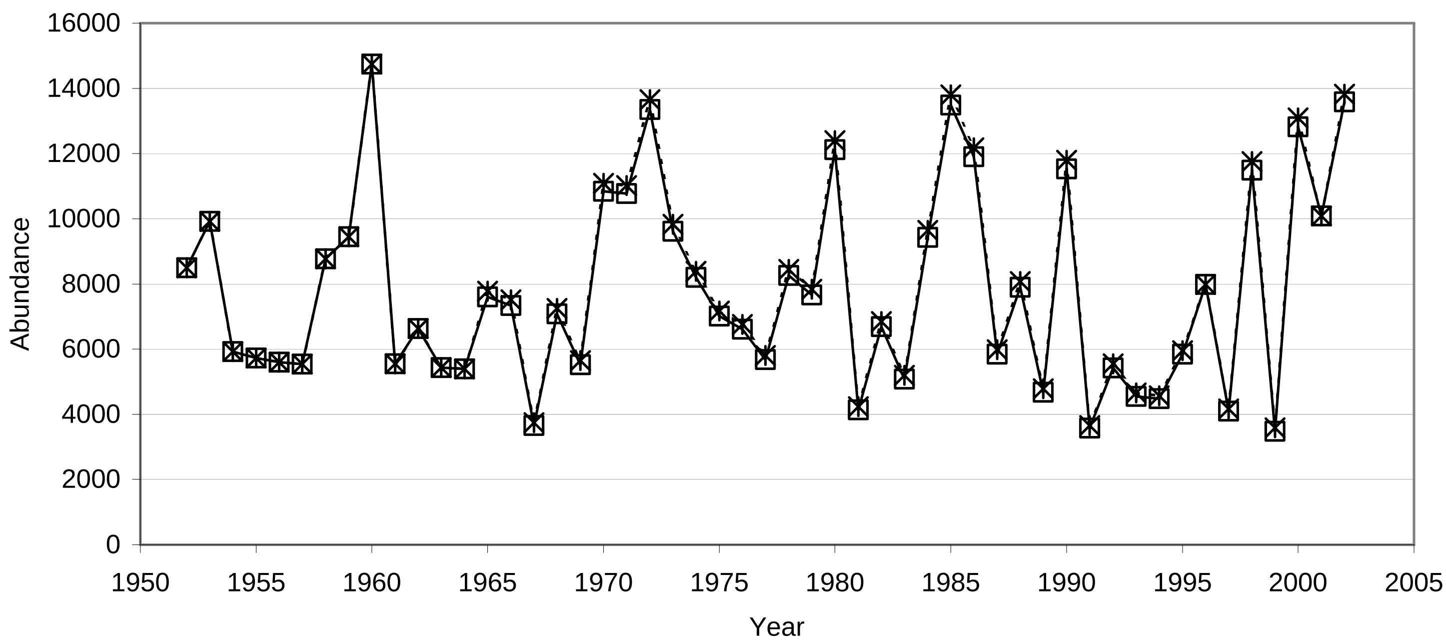
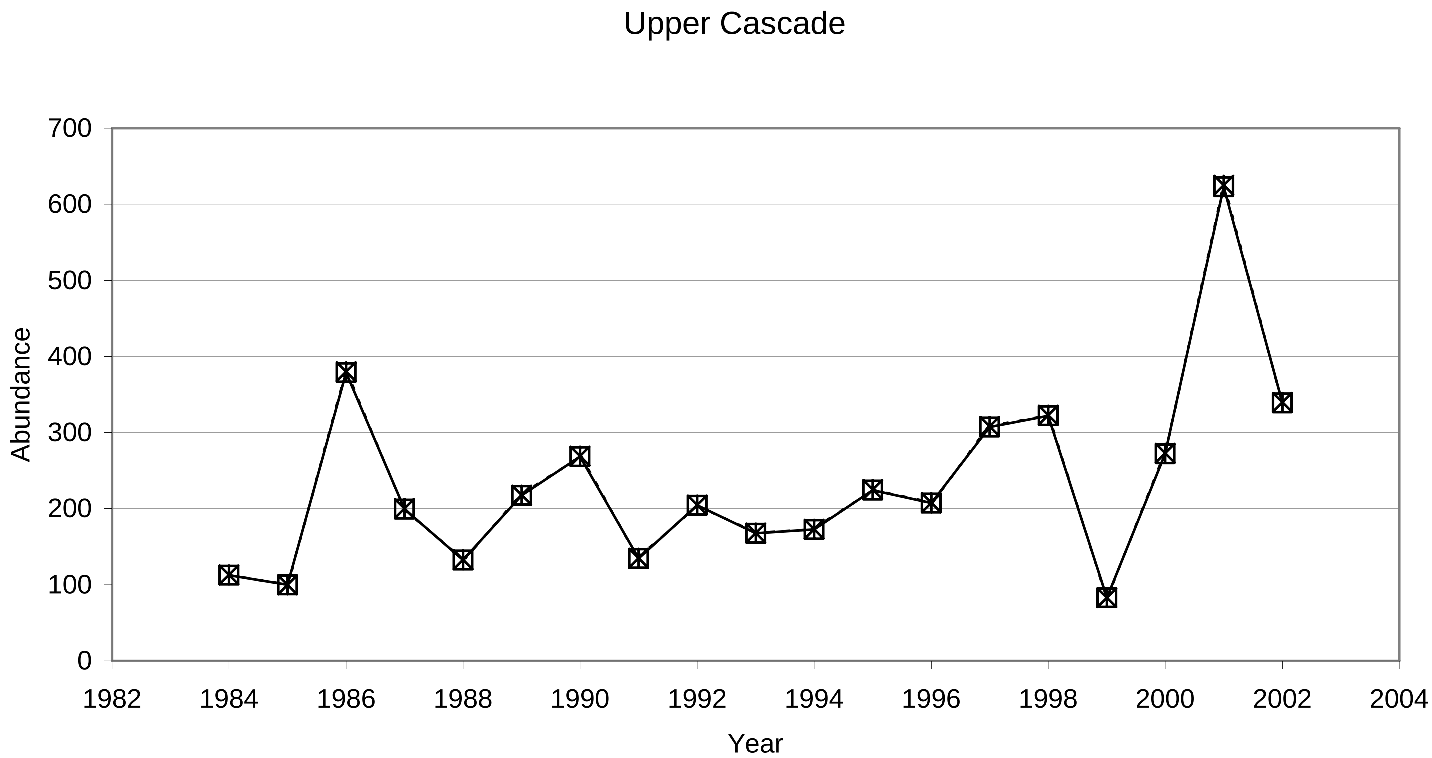


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



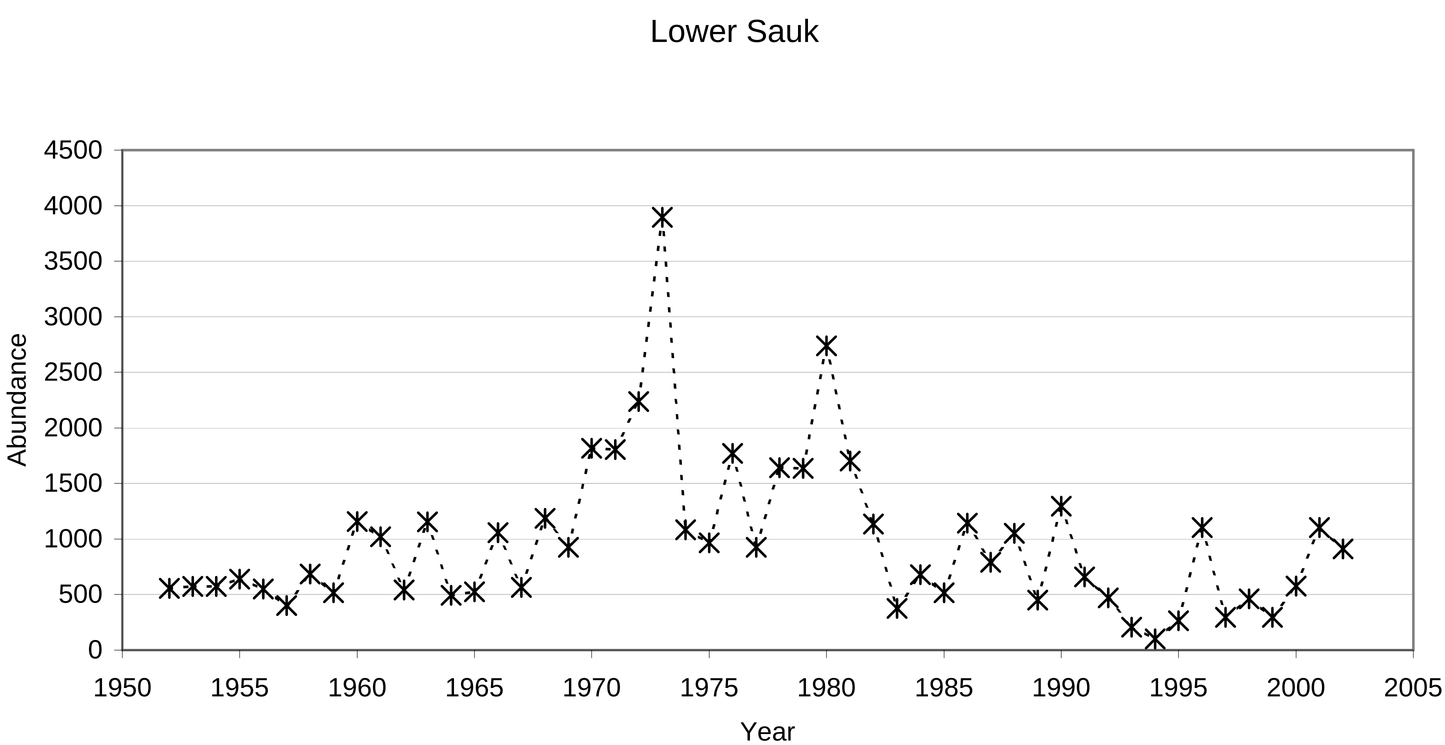
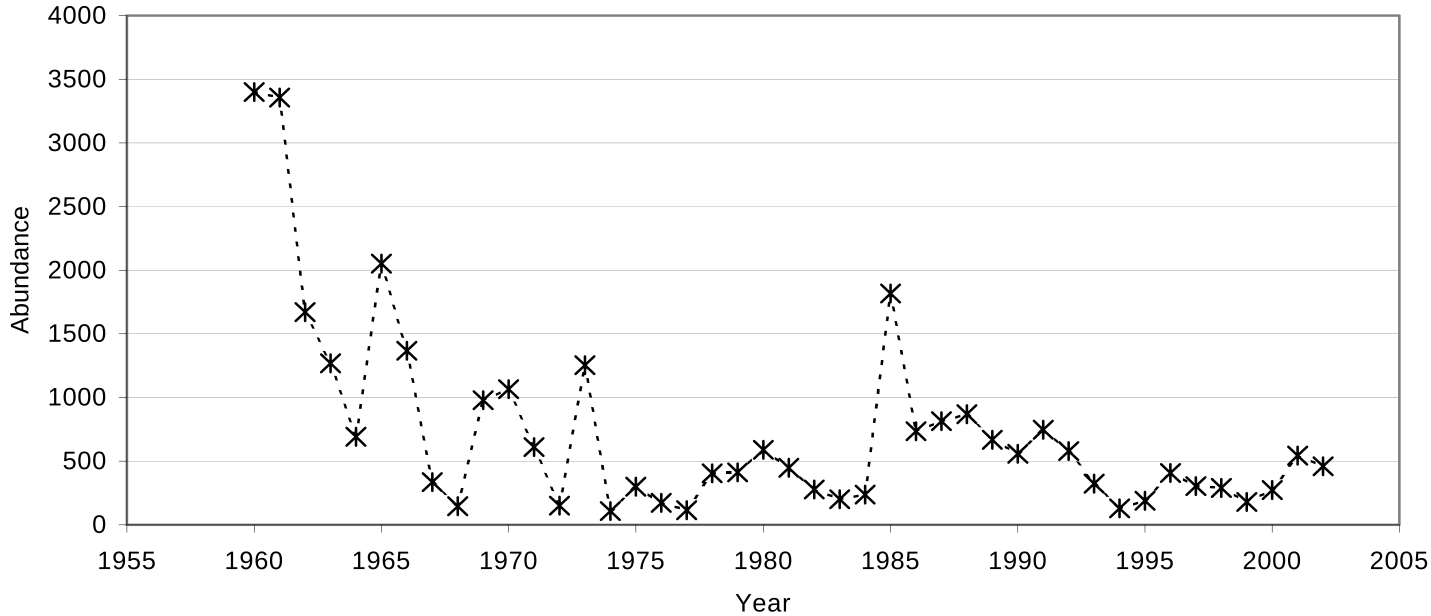


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)

Upper Sauk



Suiattle

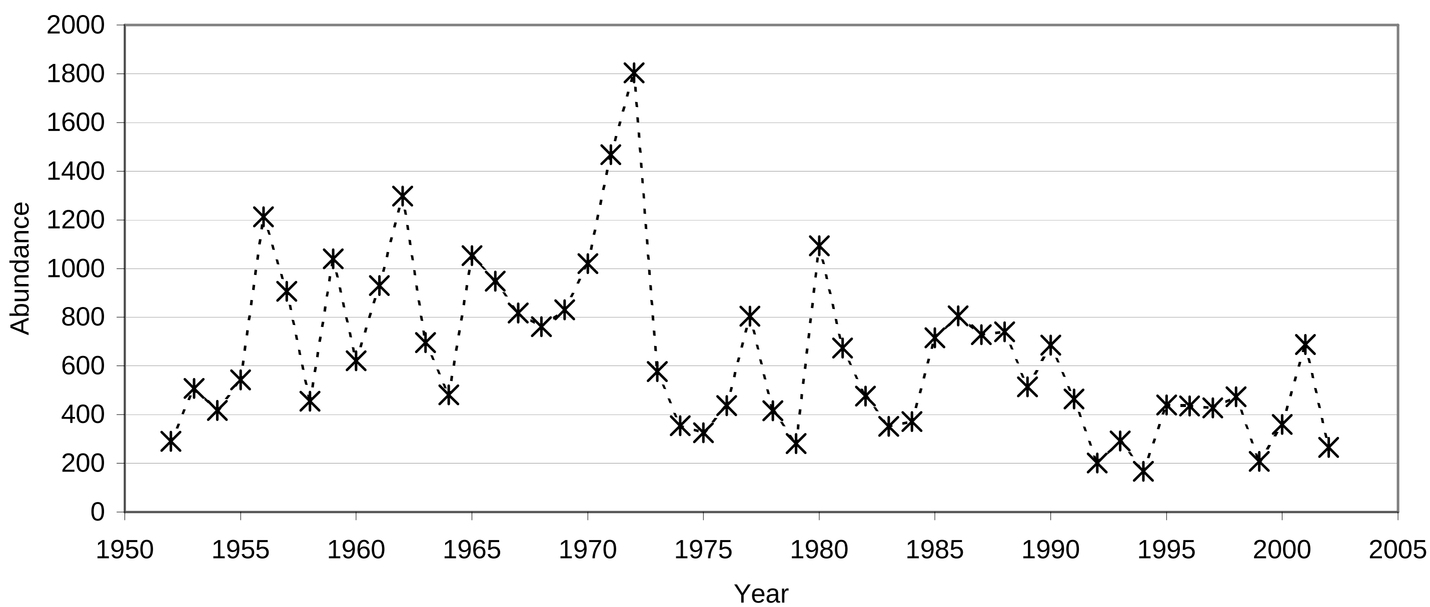
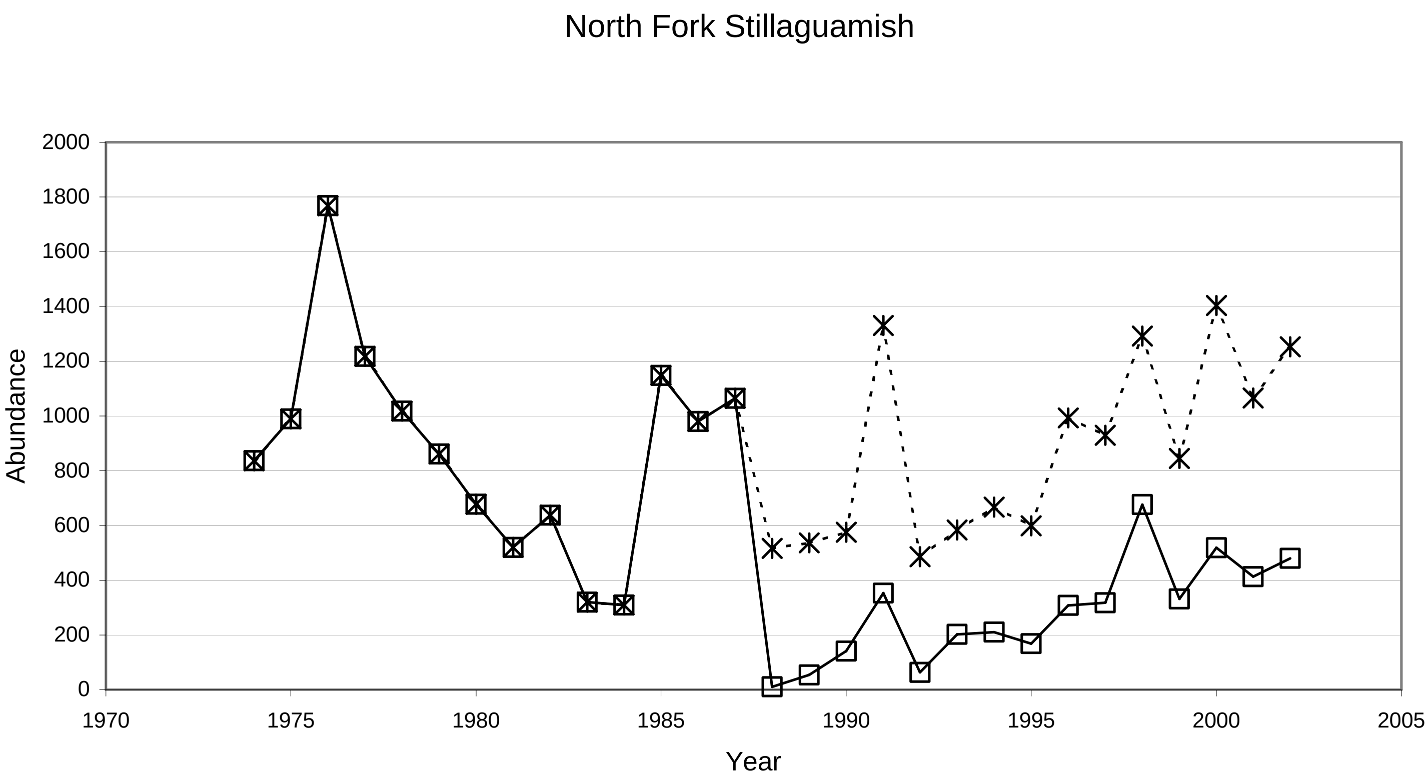


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



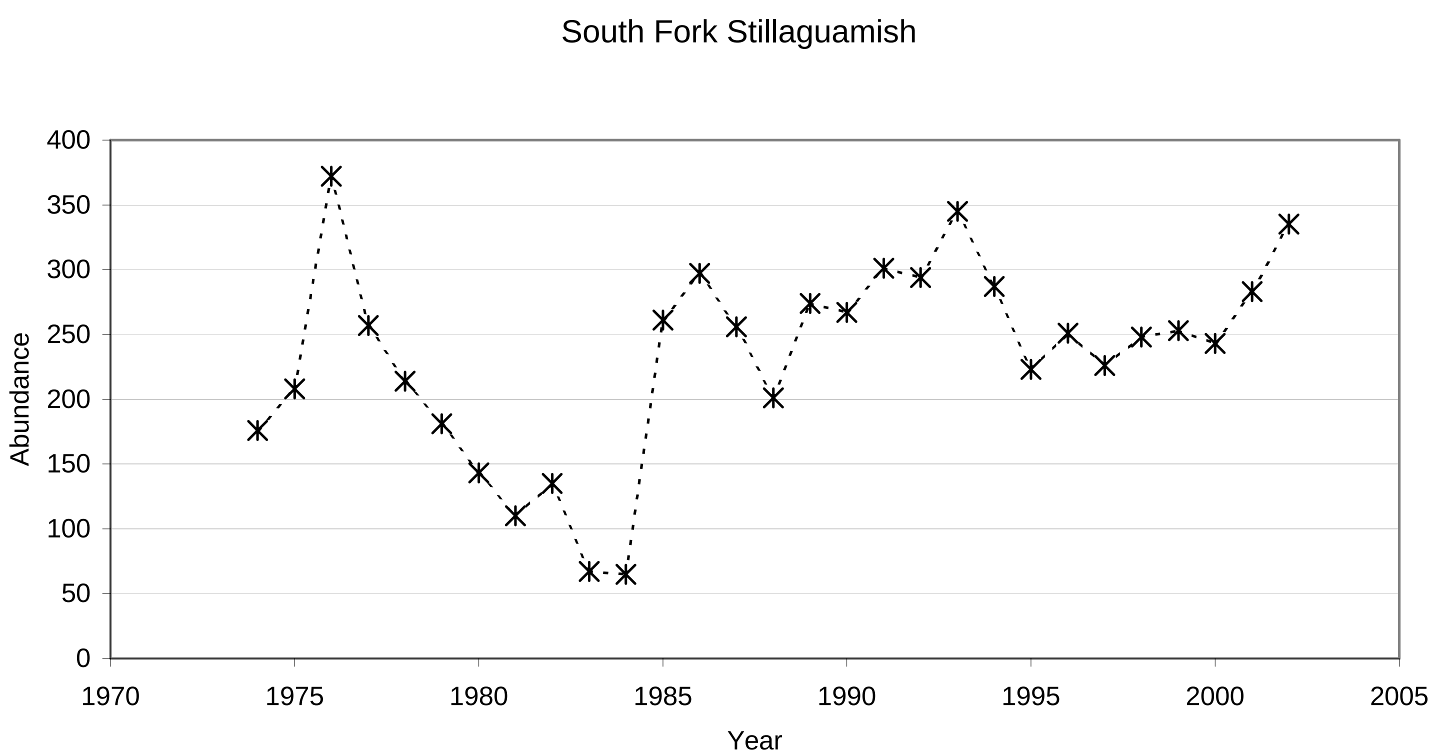
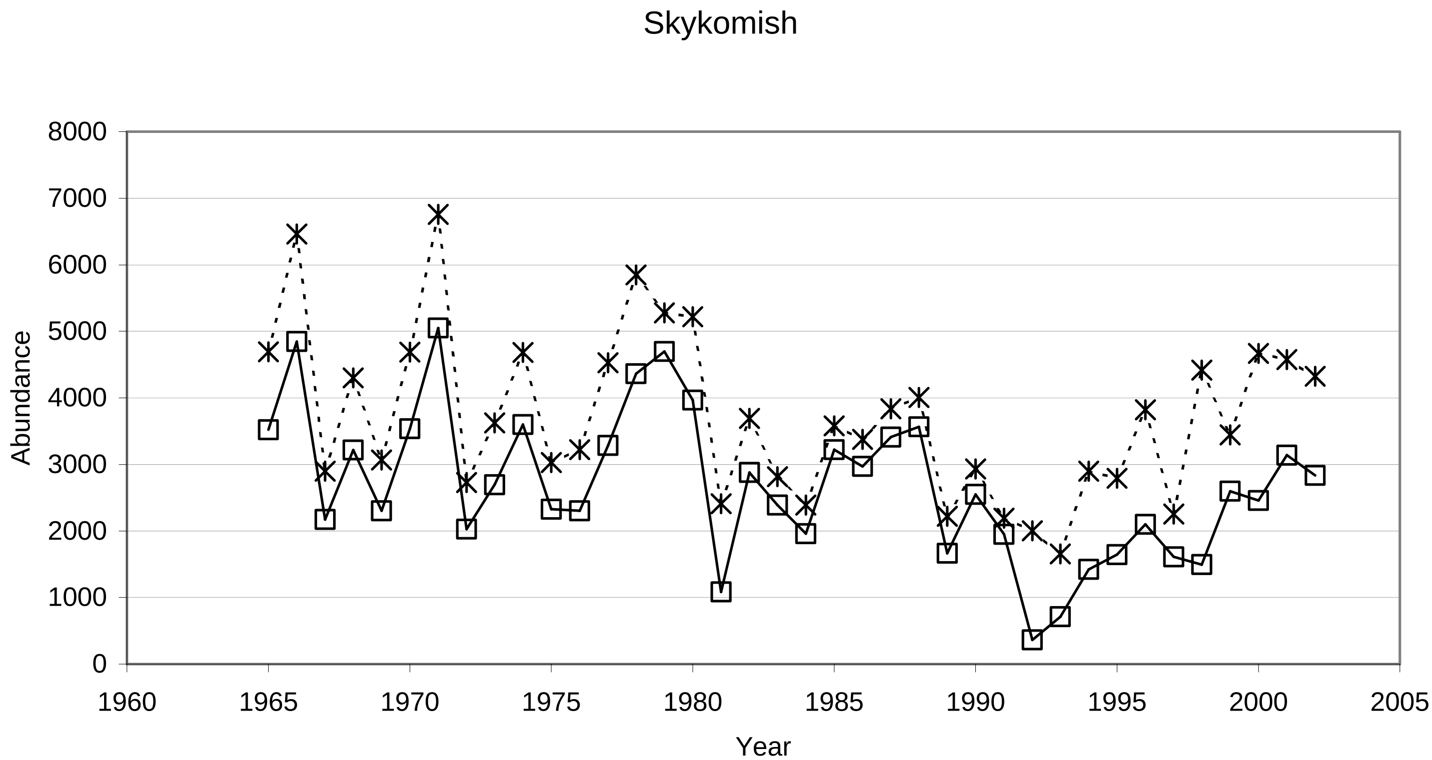


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



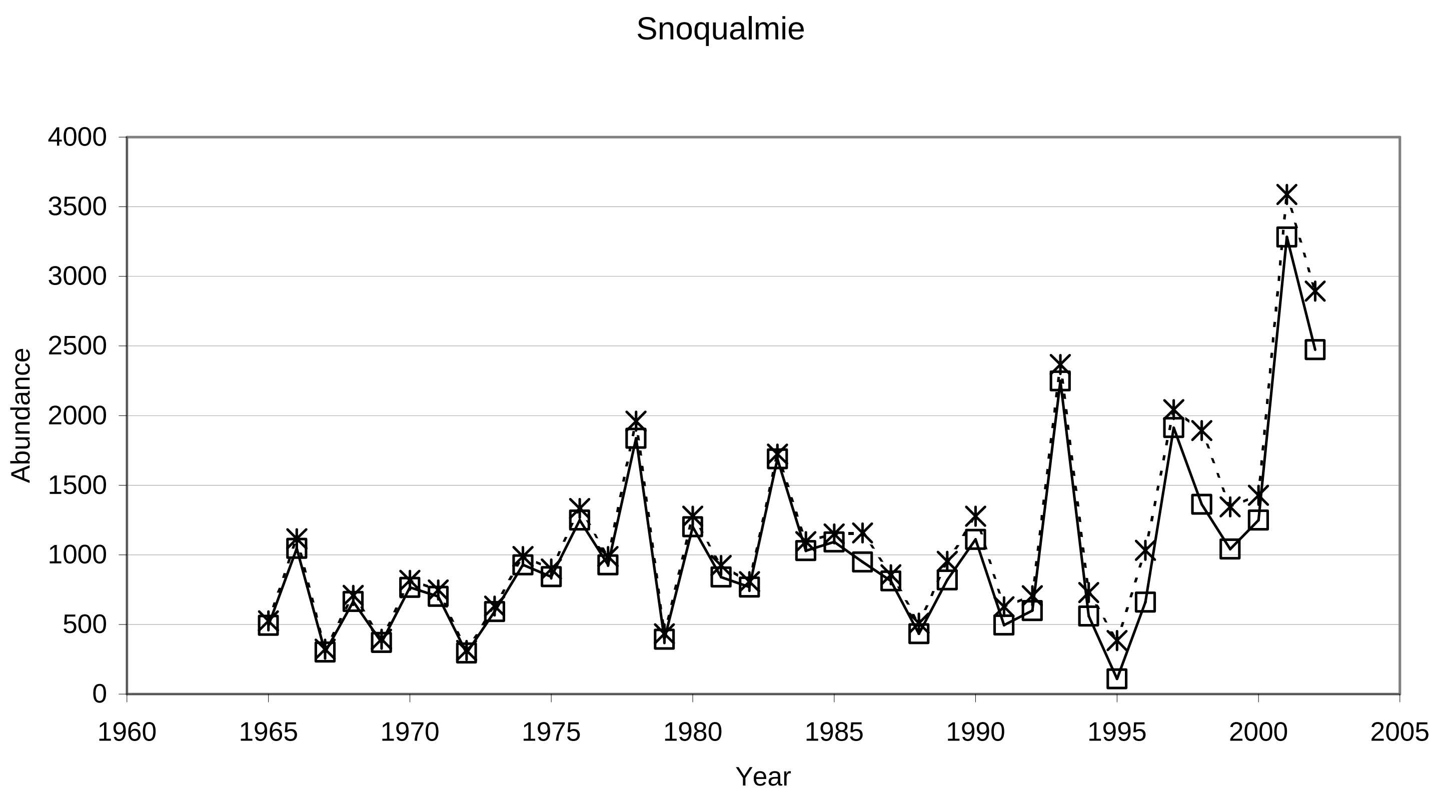
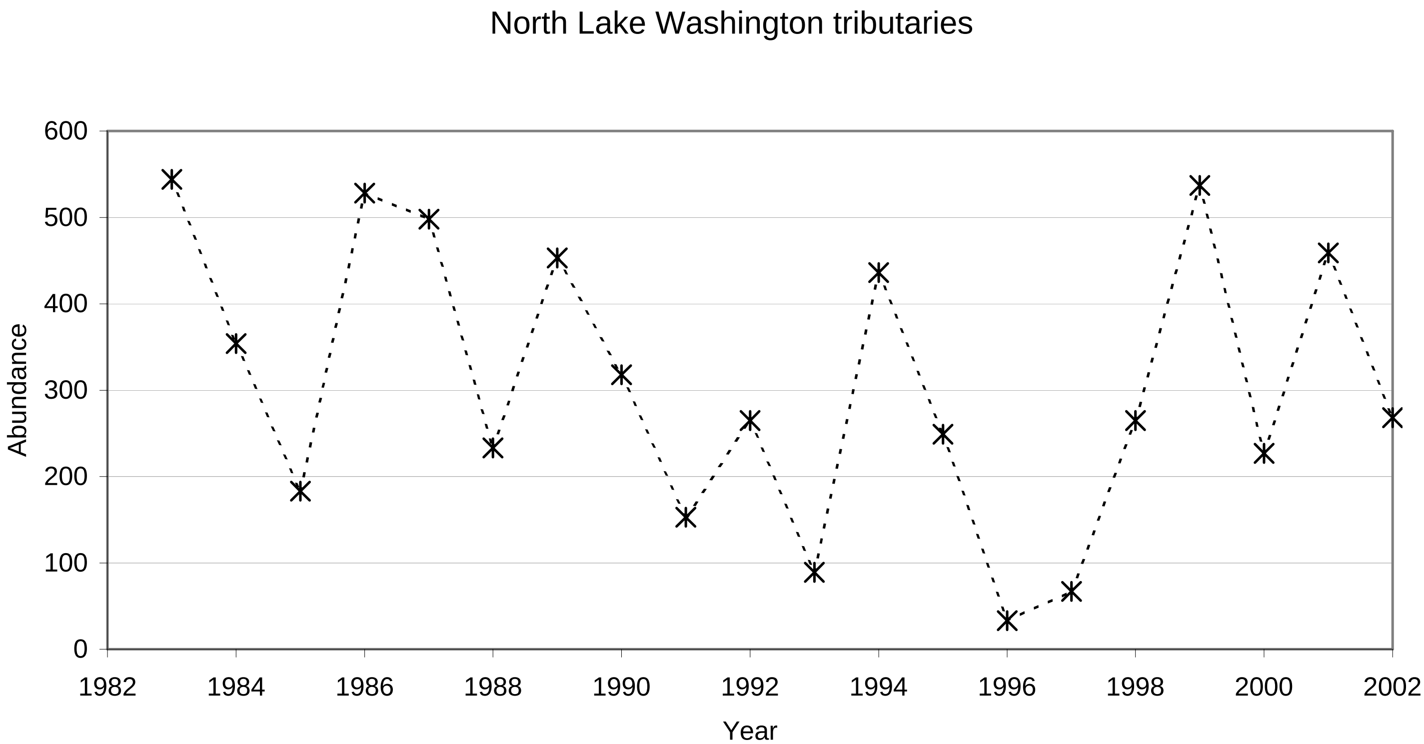


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



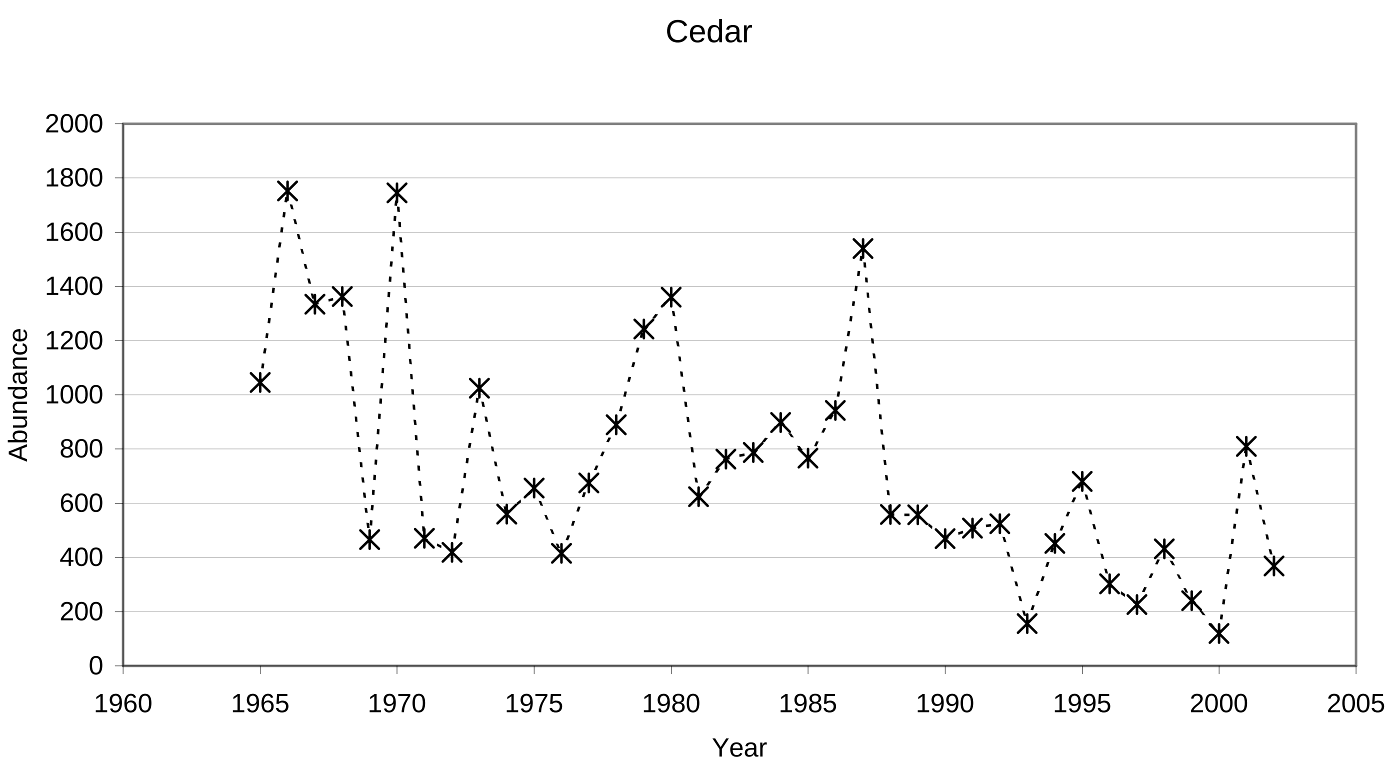
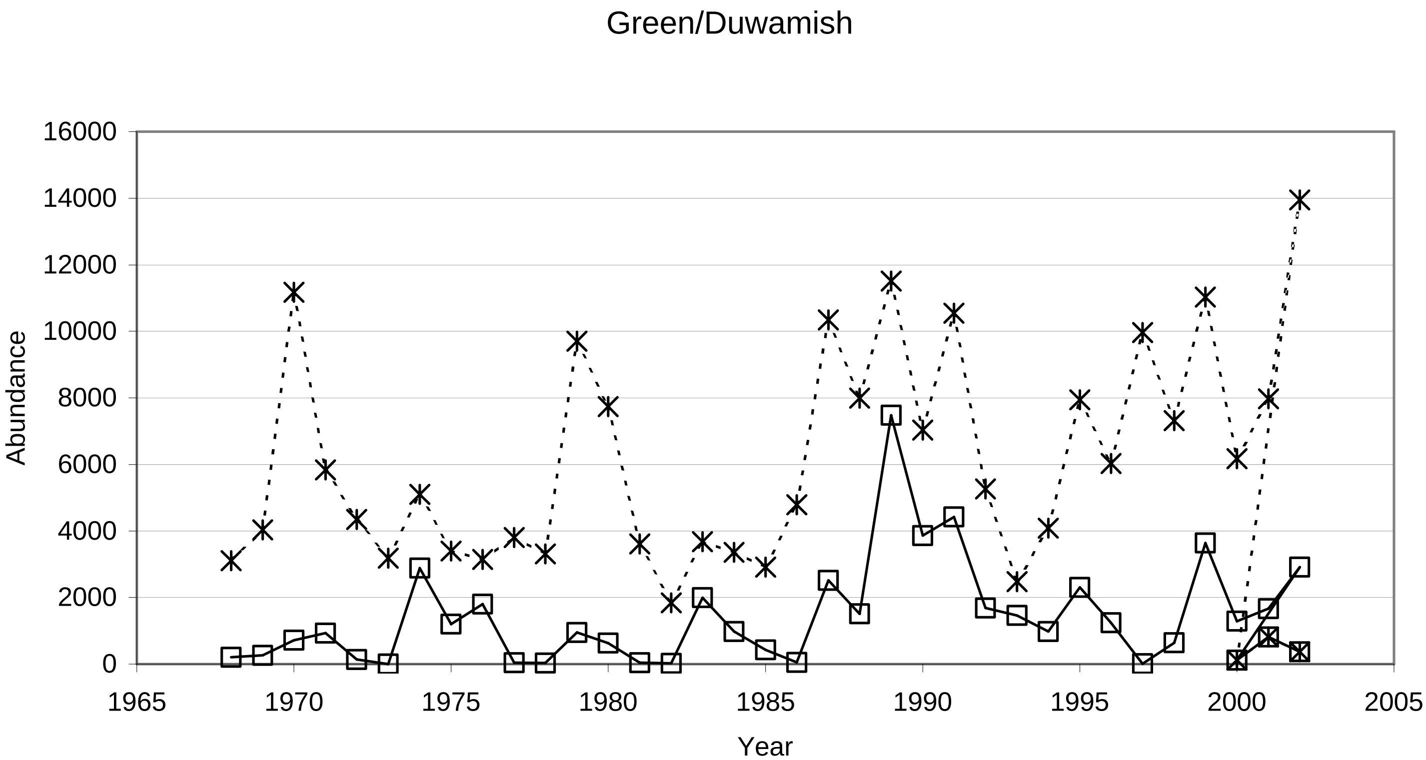


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



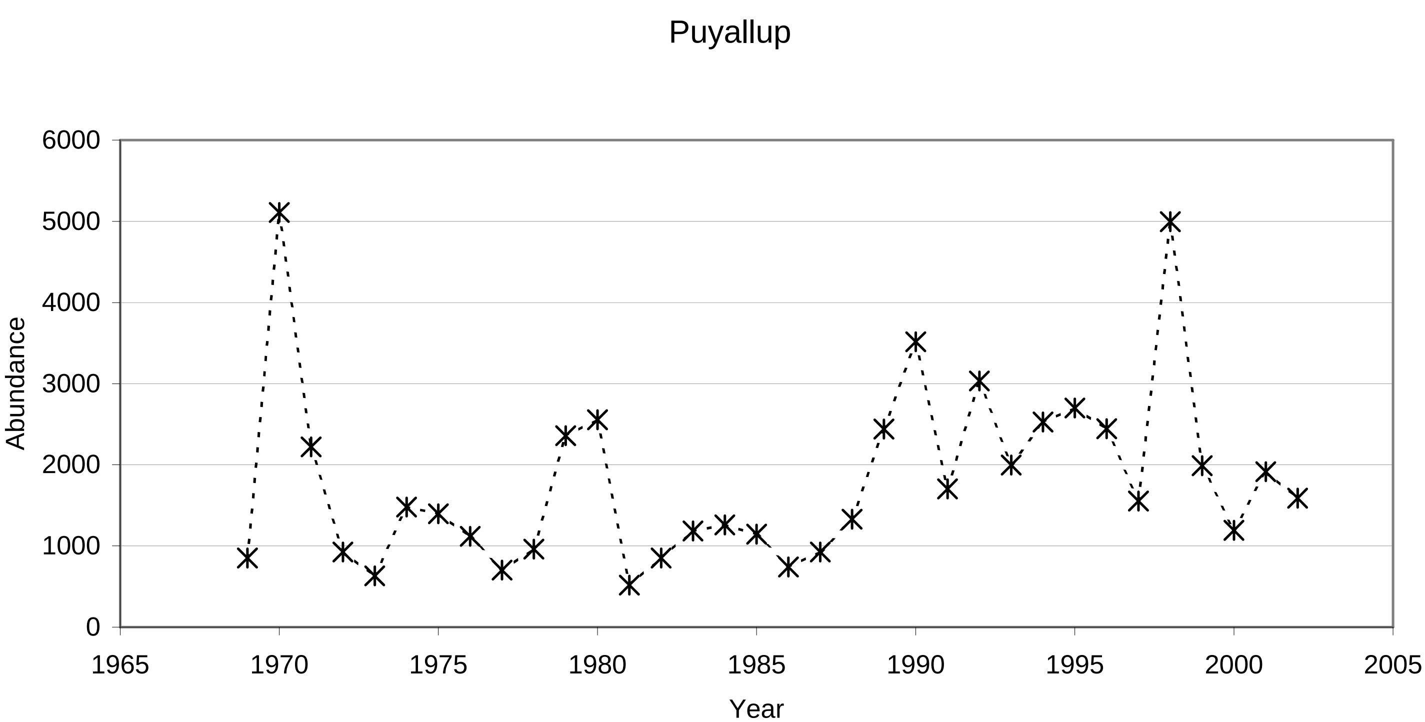
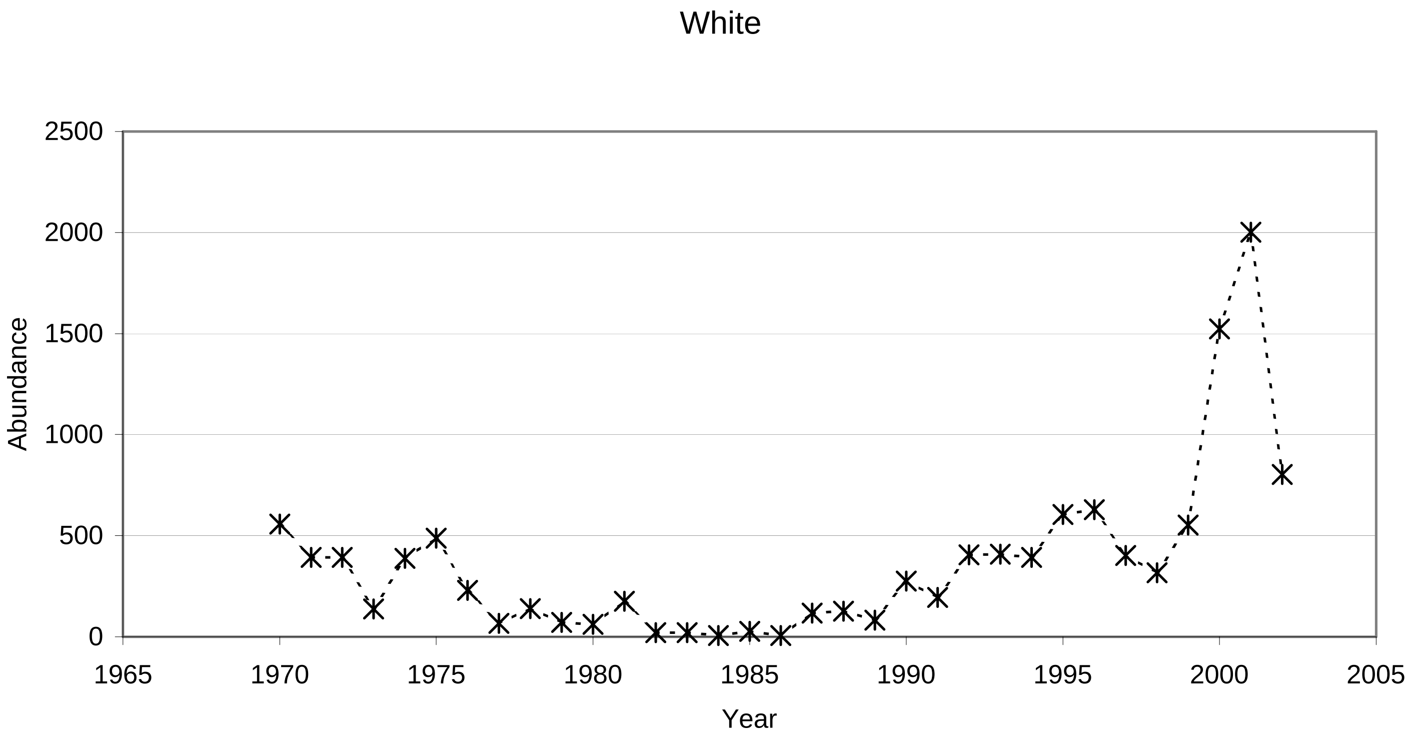


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



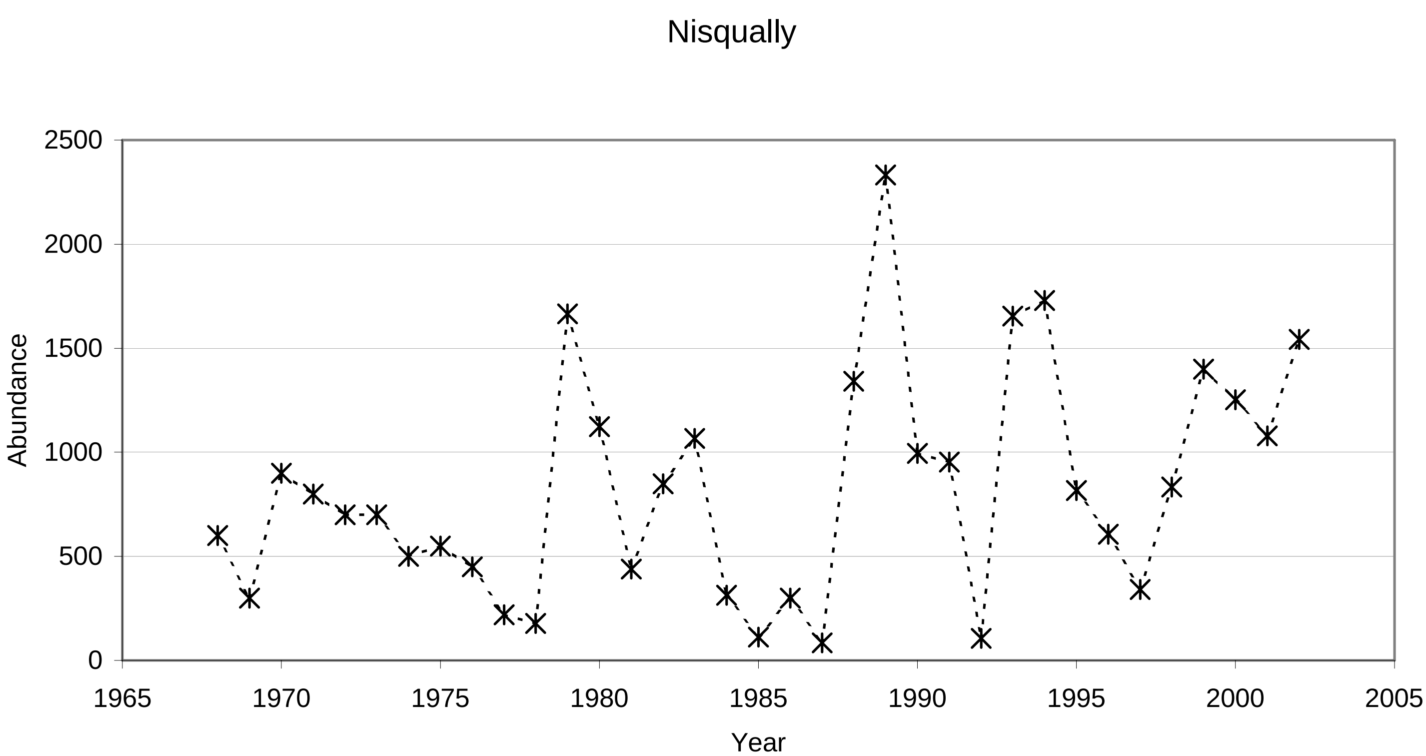
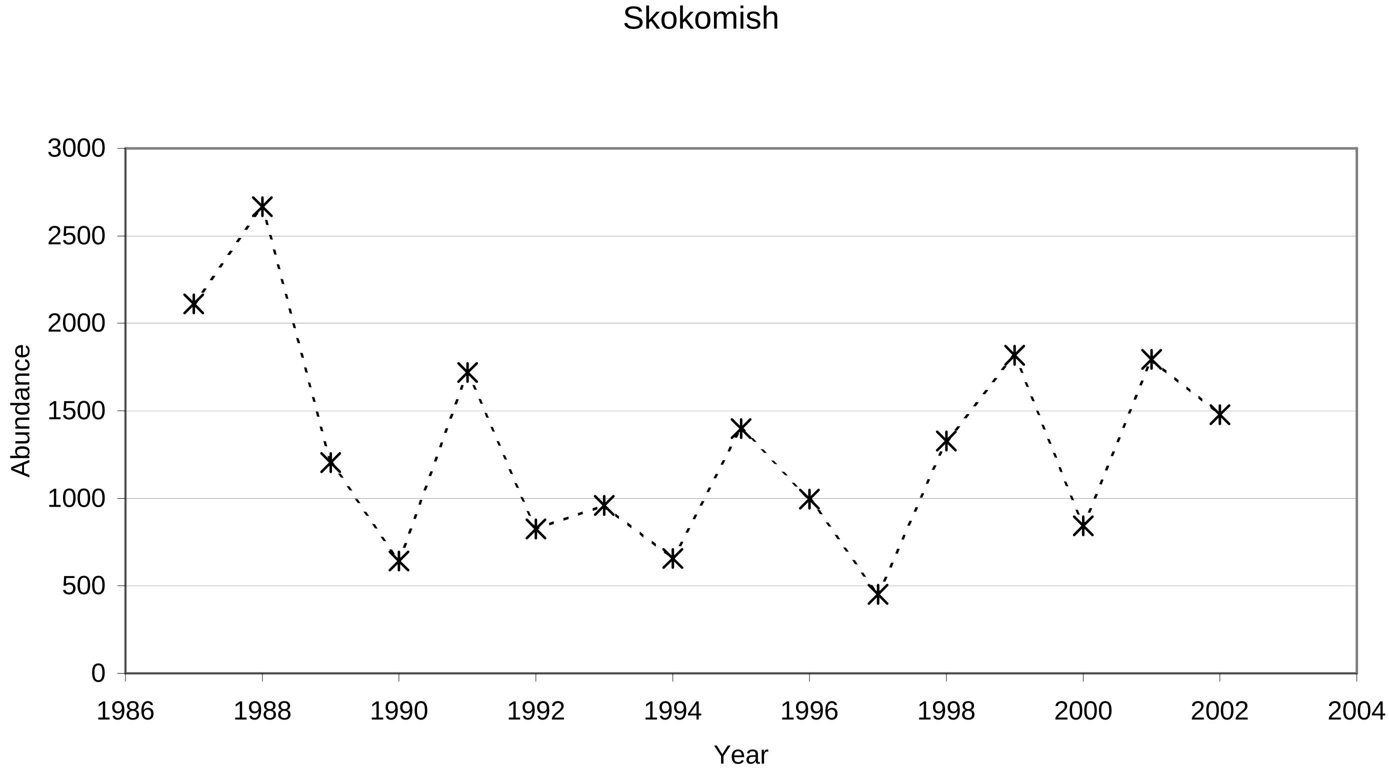


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



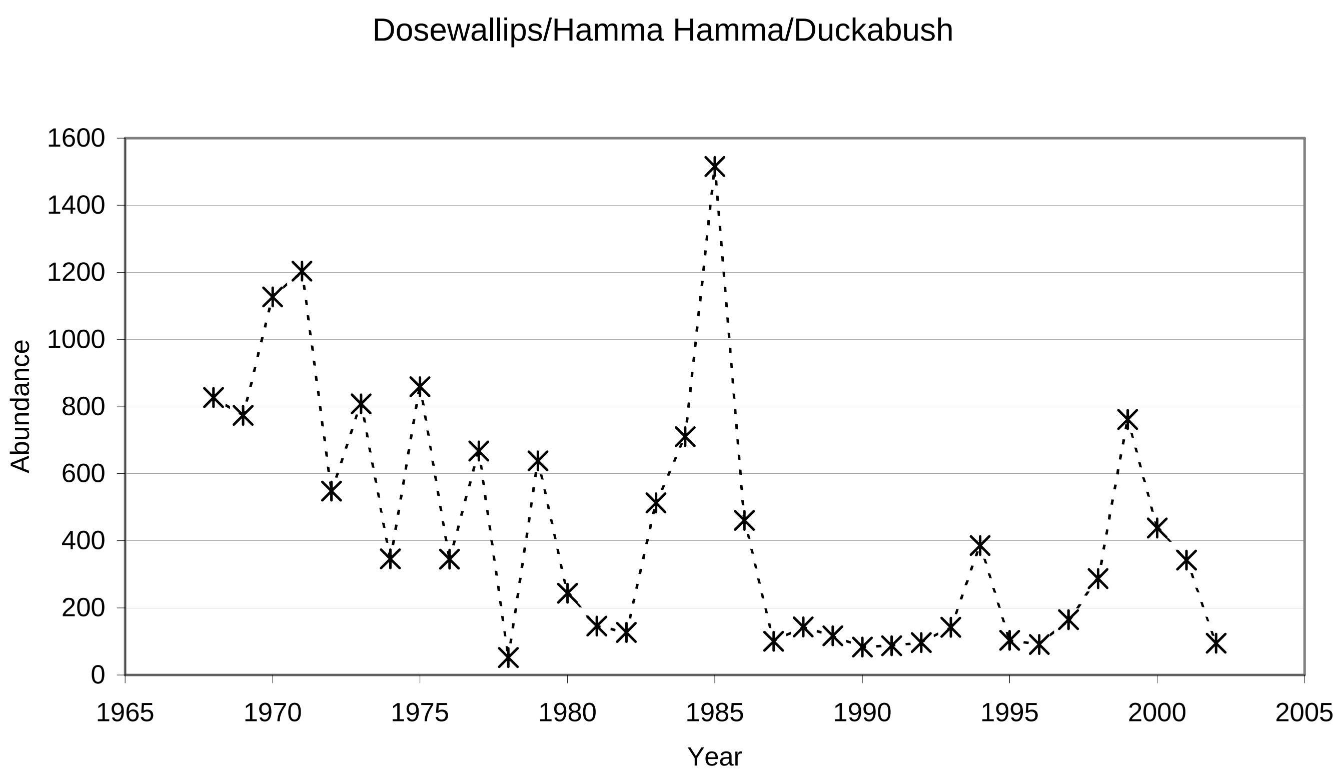
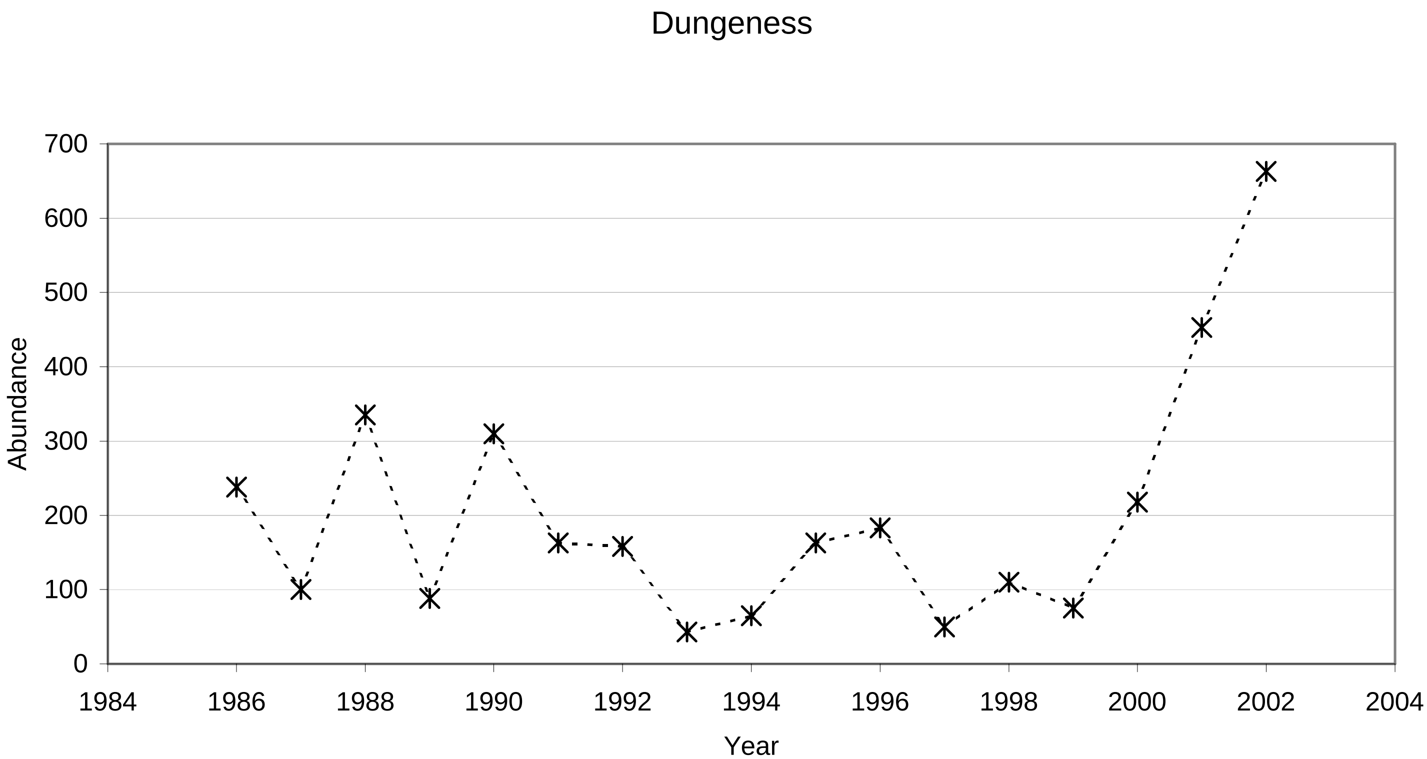


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



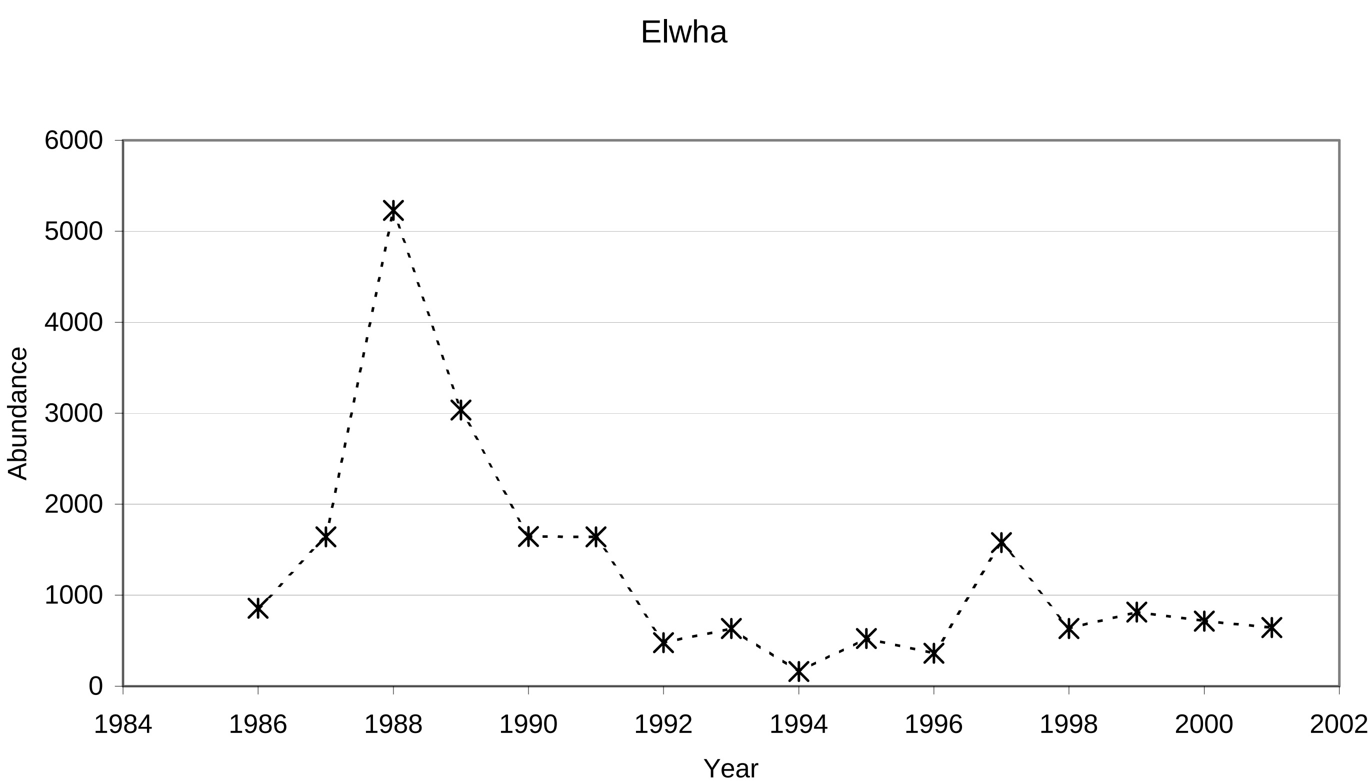
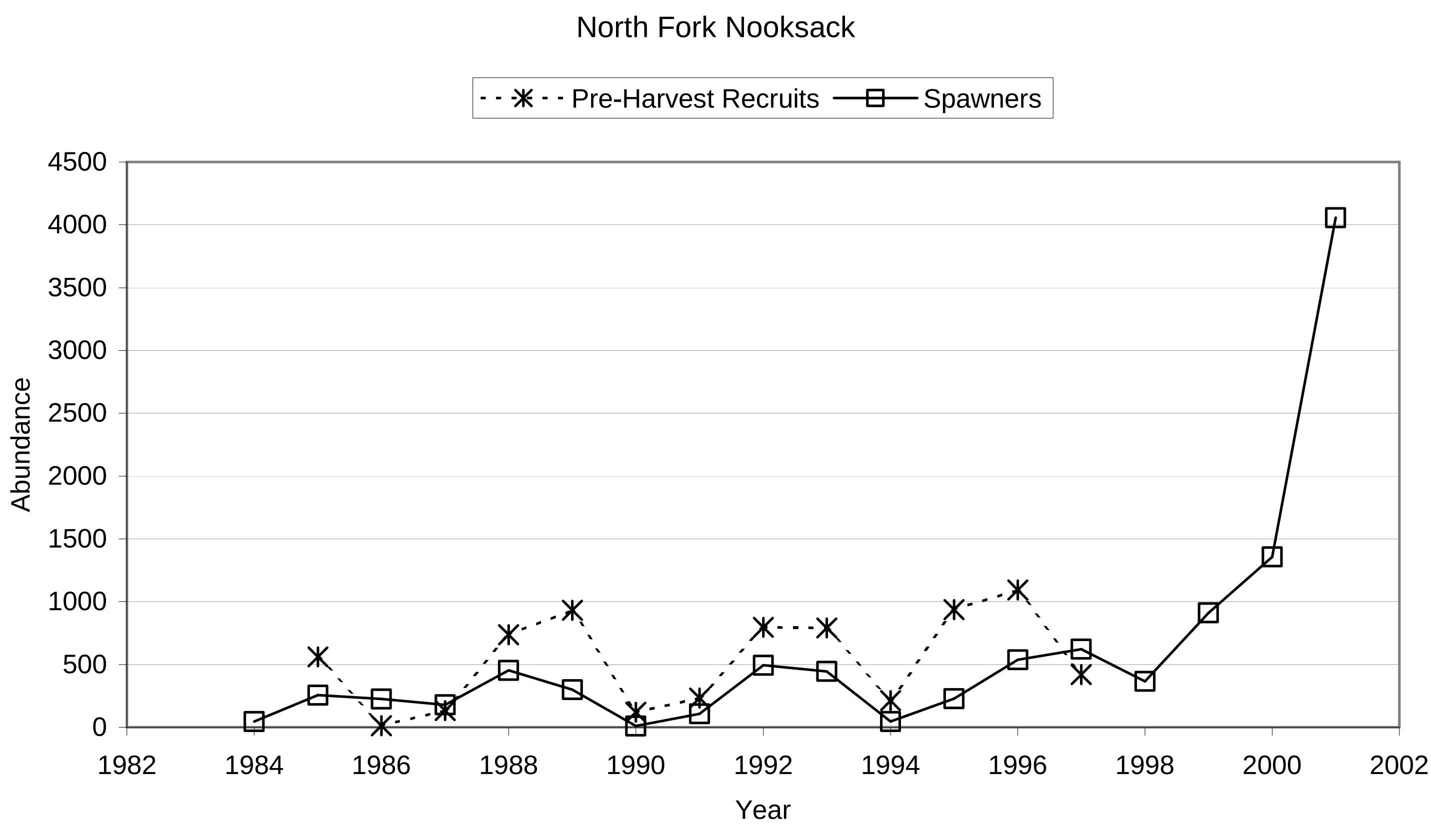


Figure A.2.4.2. Puget Sound Chinook pre-harvest recruits and spawners vs. brood year by population



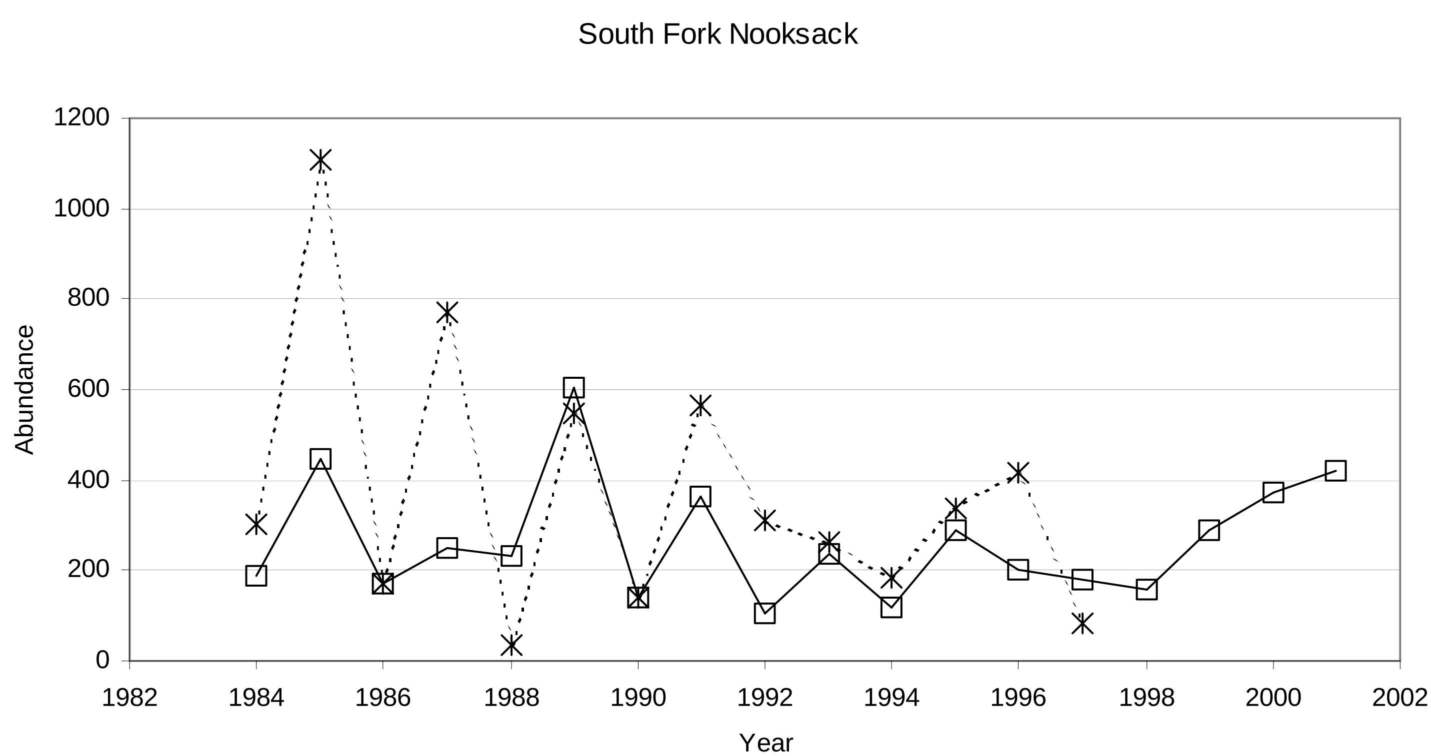
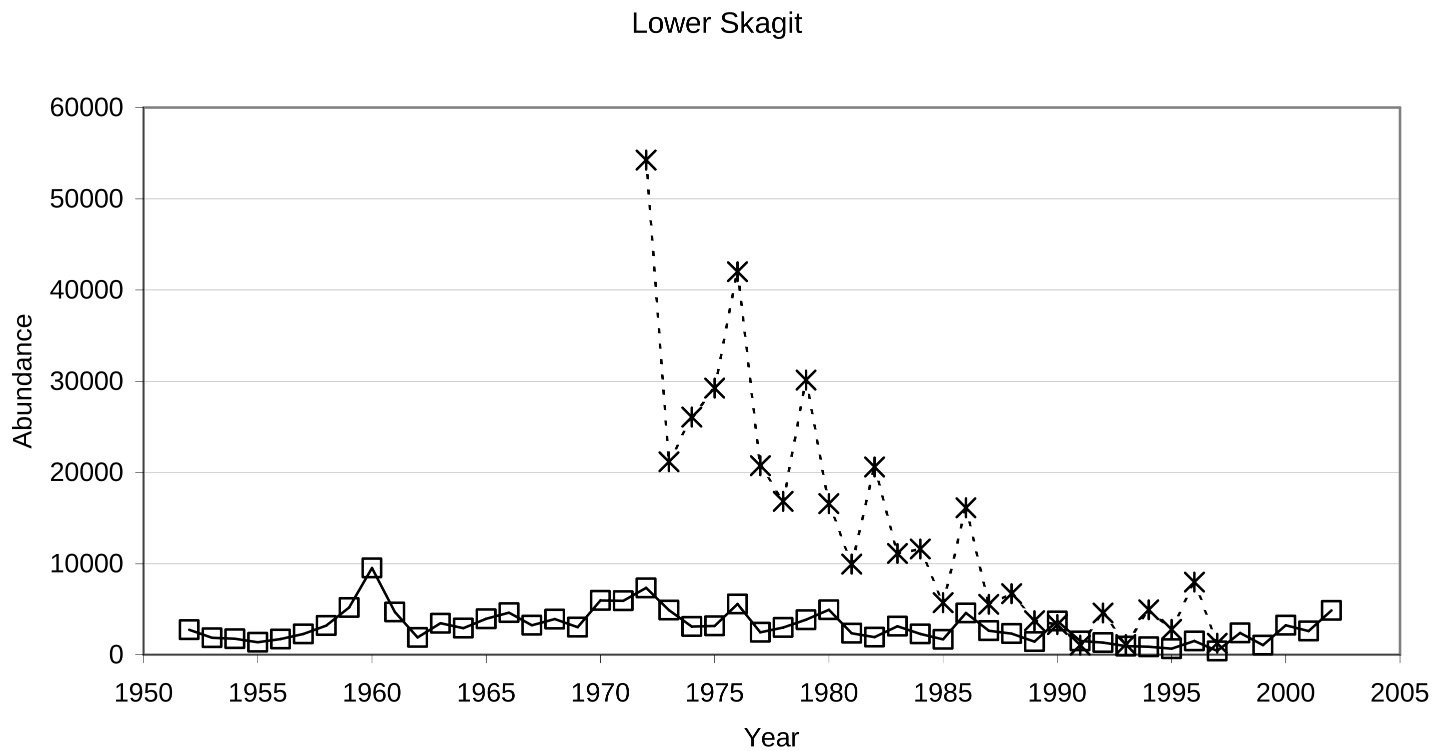


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



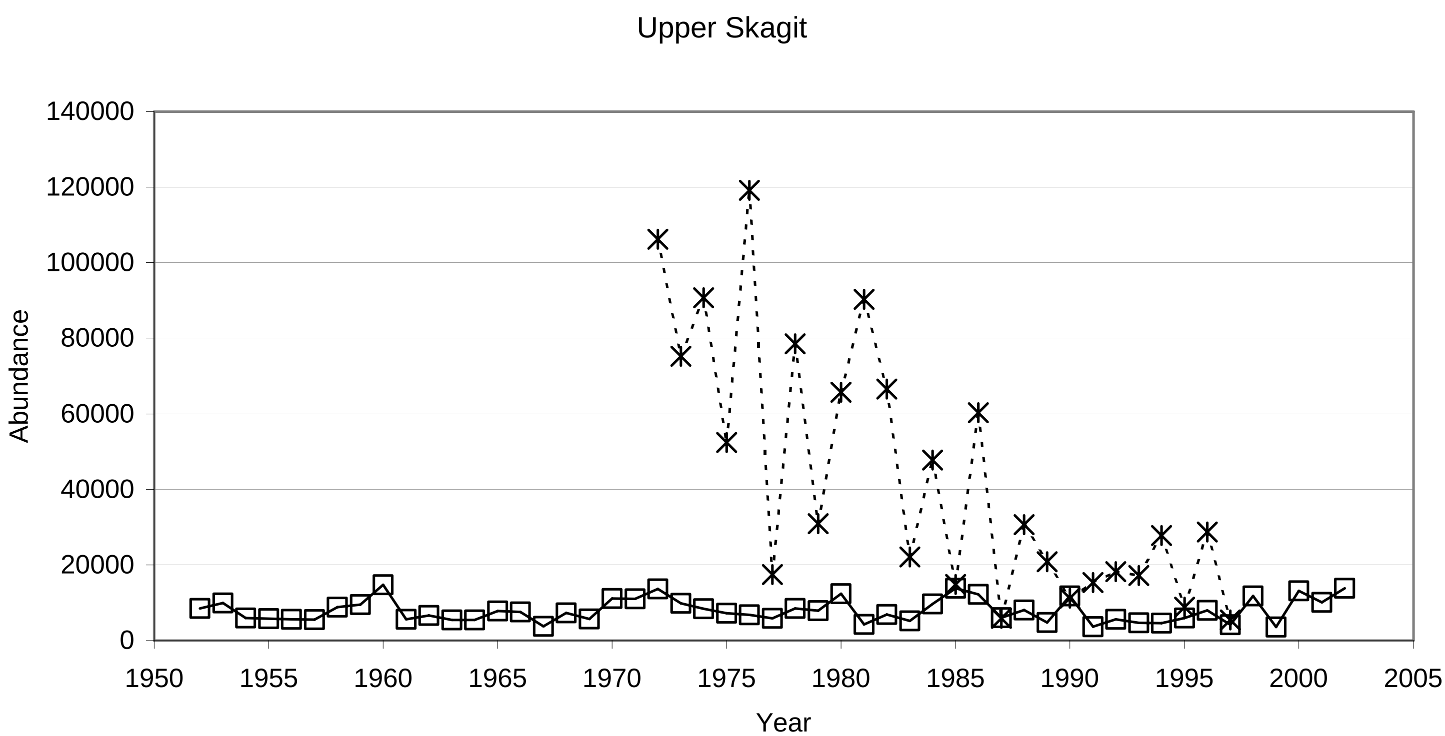
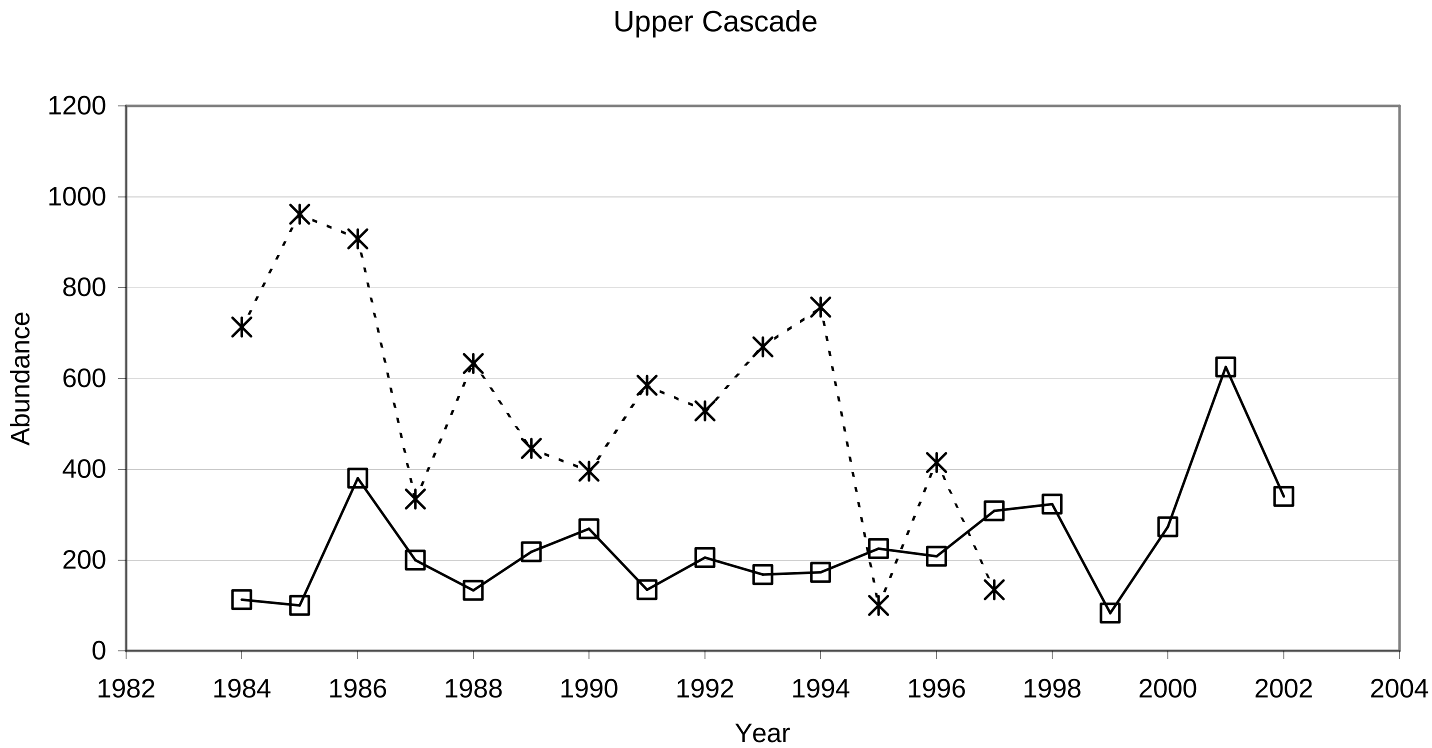


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



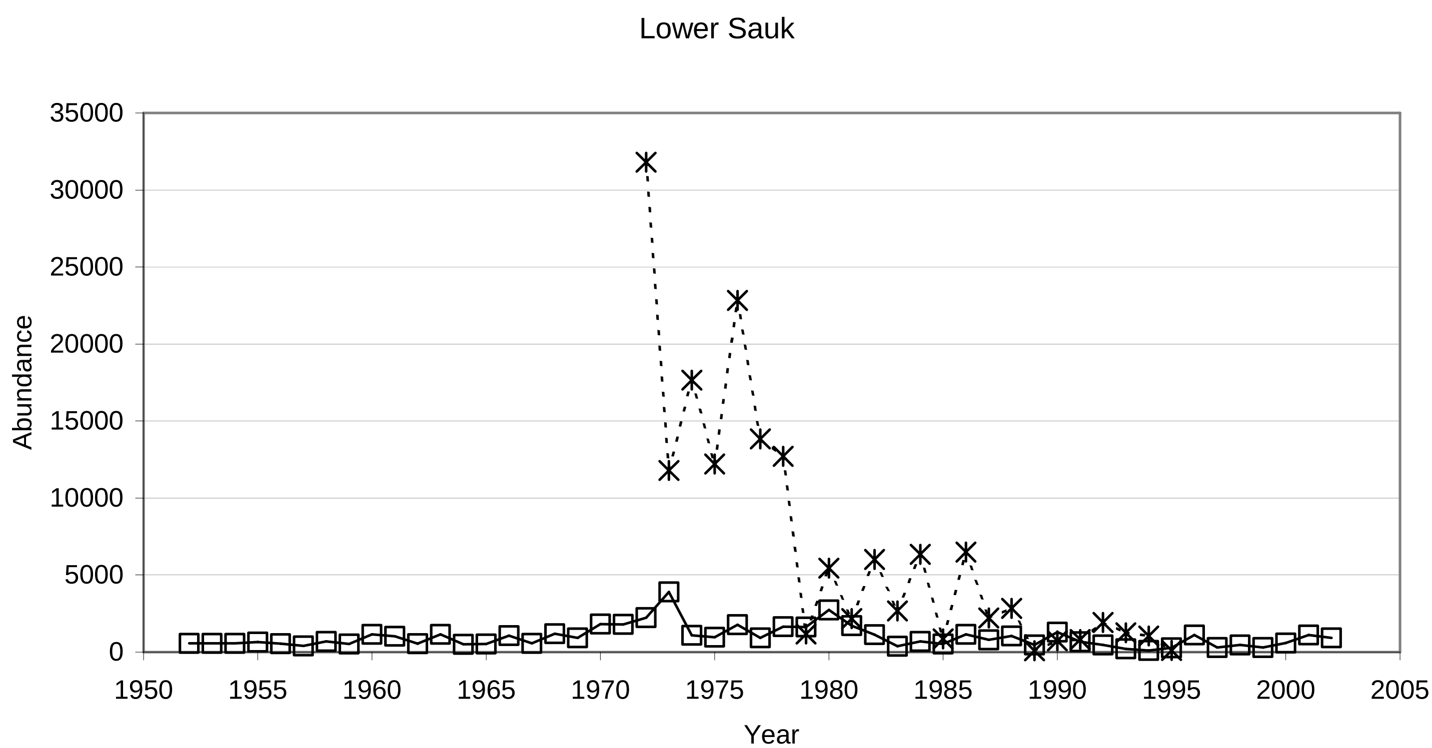
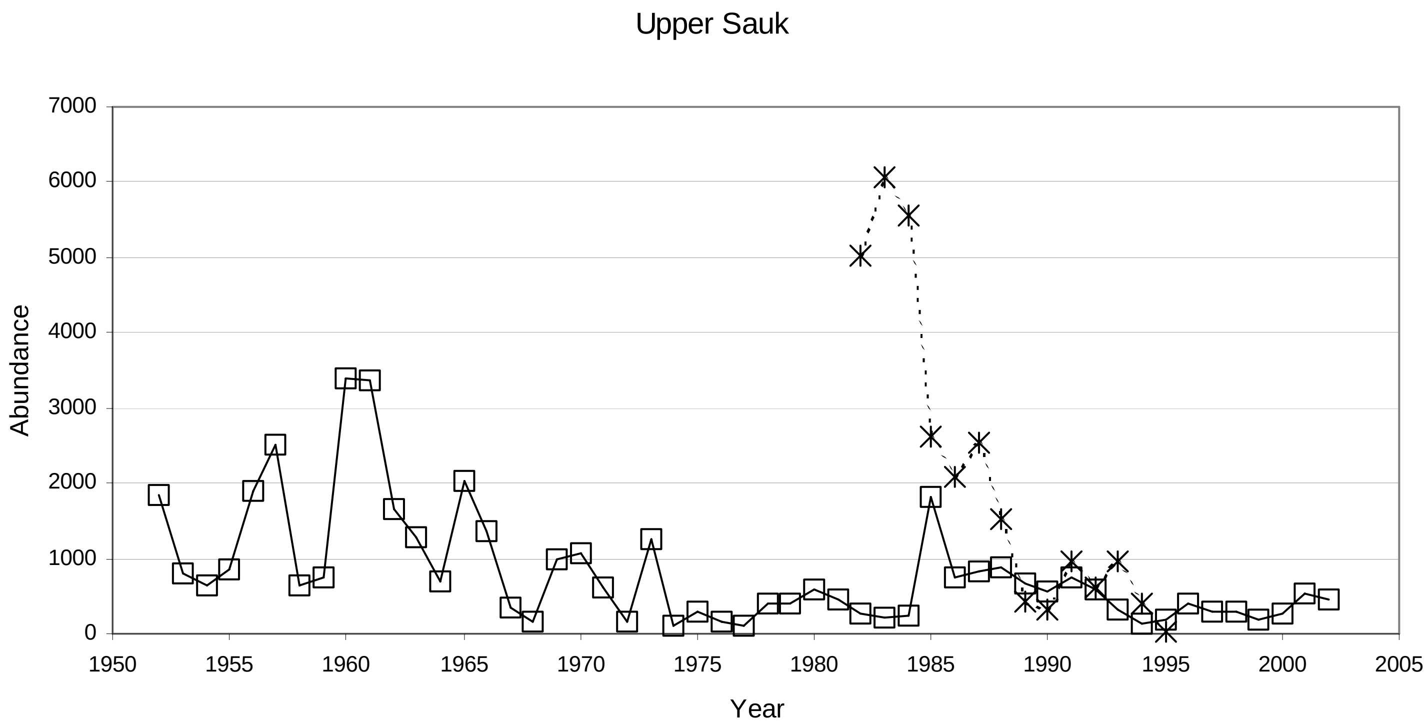


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



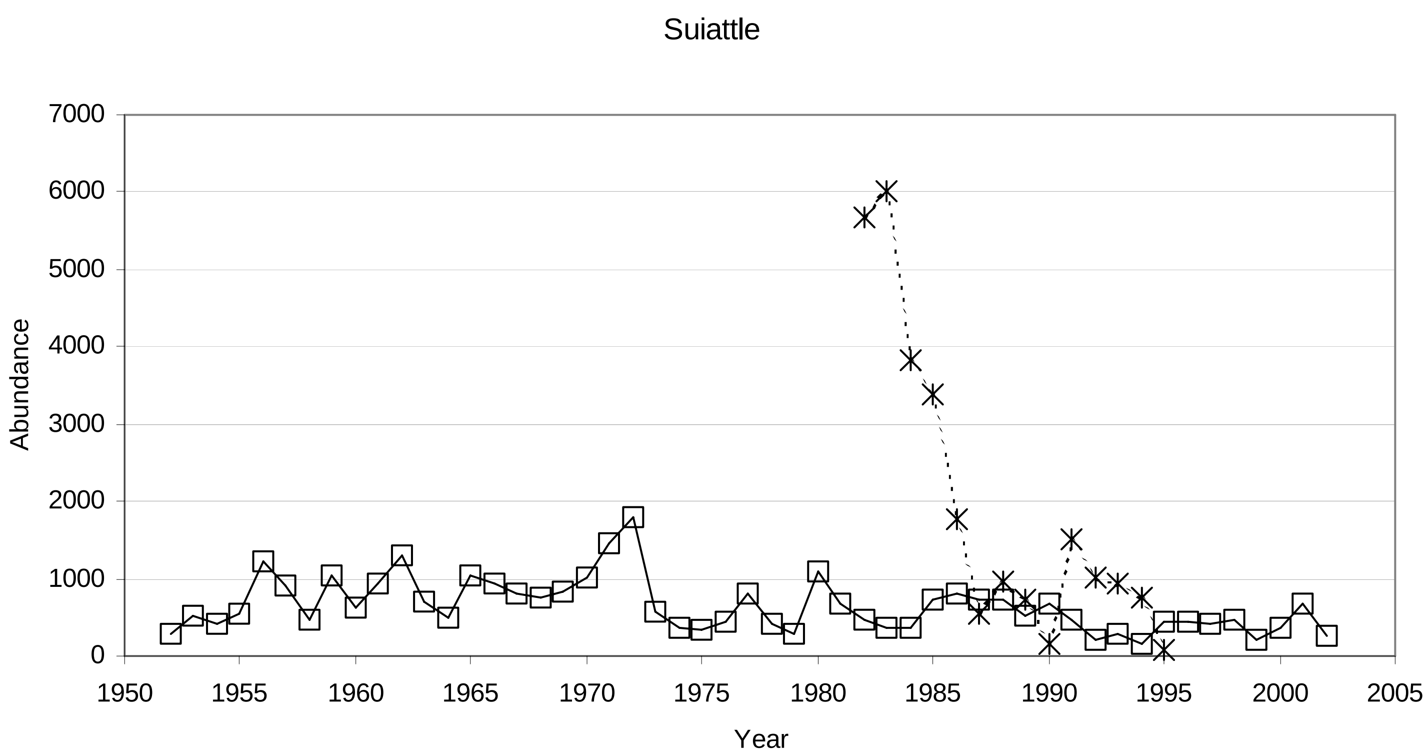
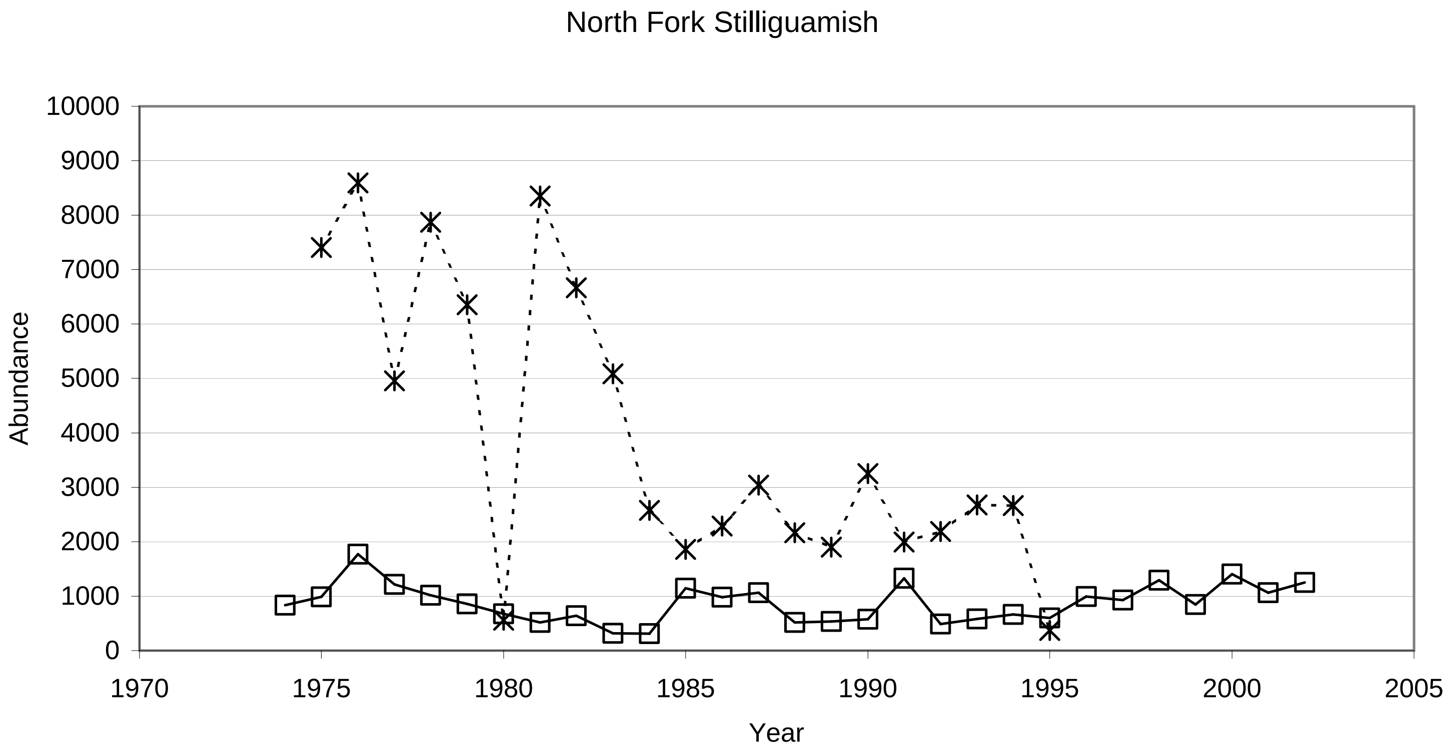


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



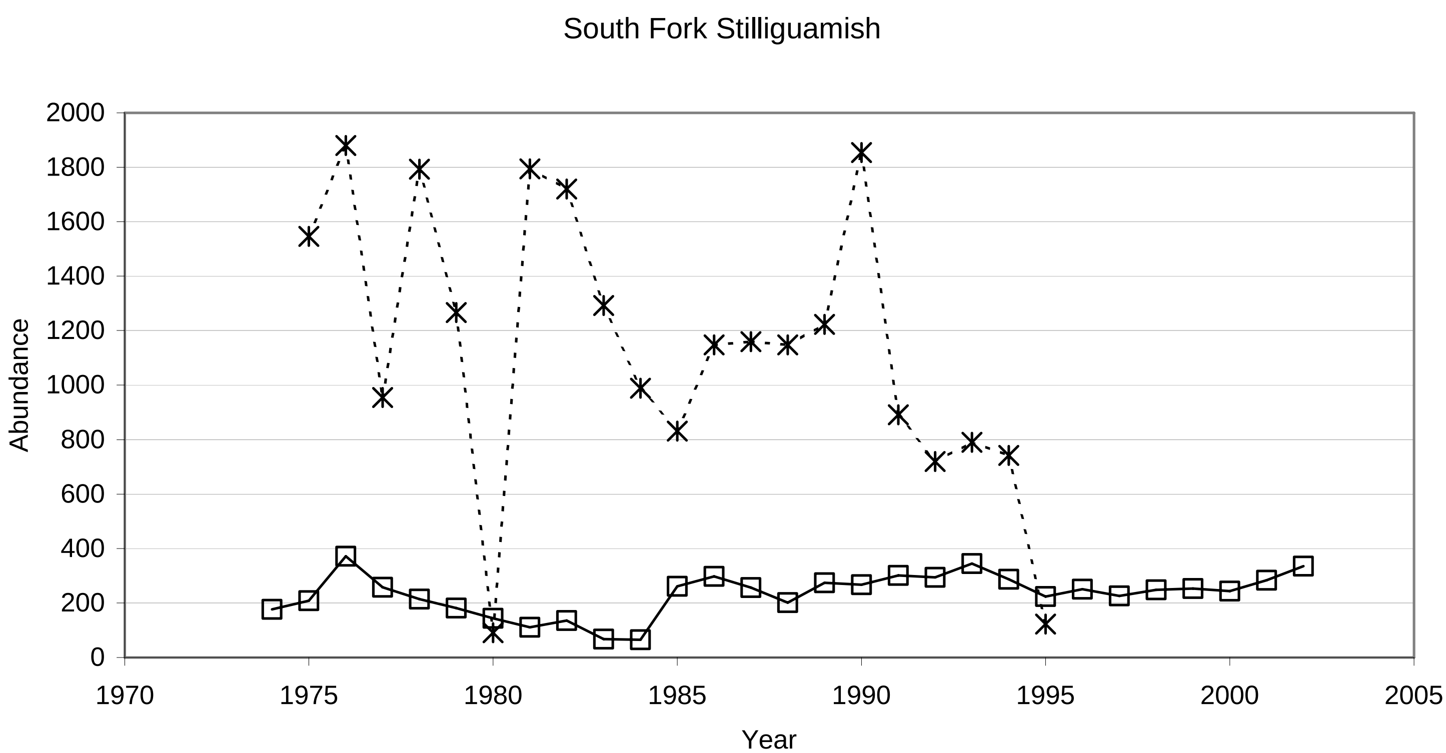
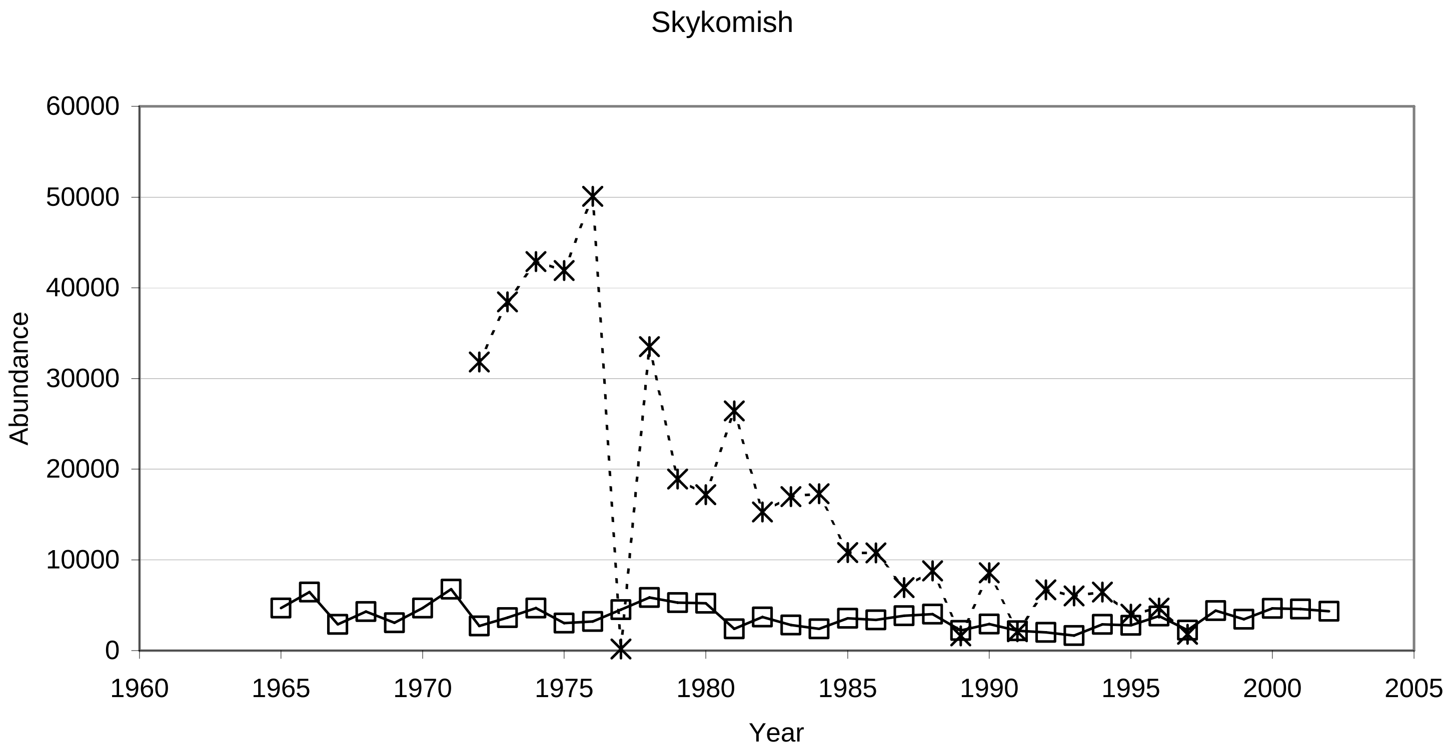


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



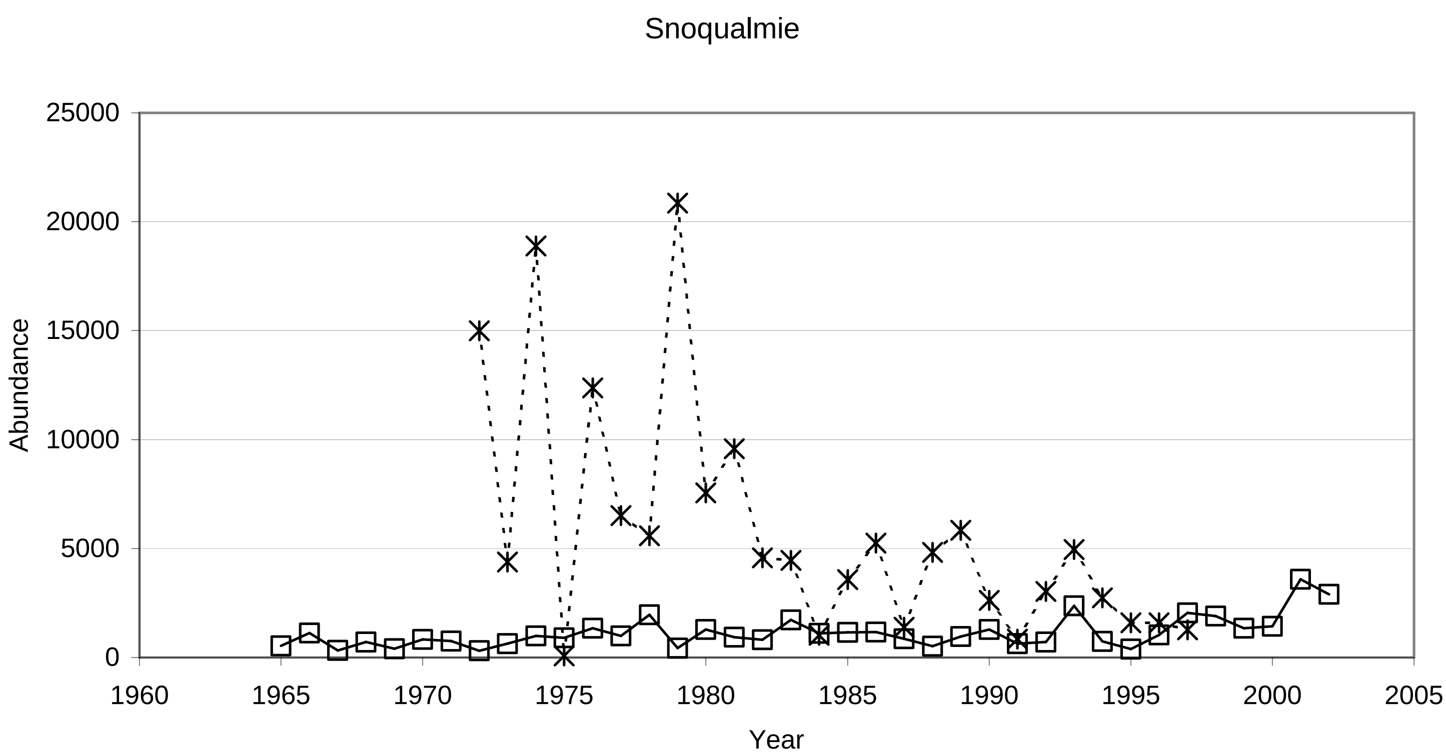
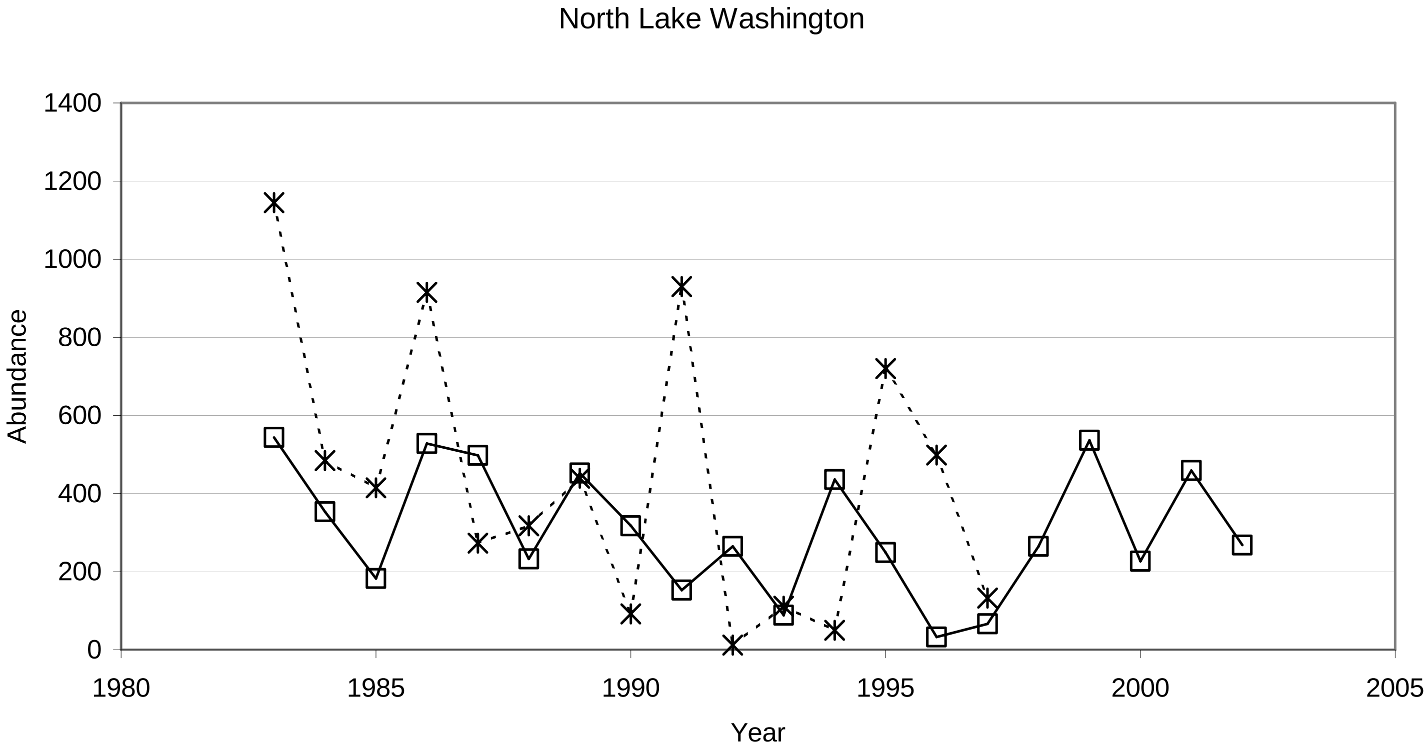


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



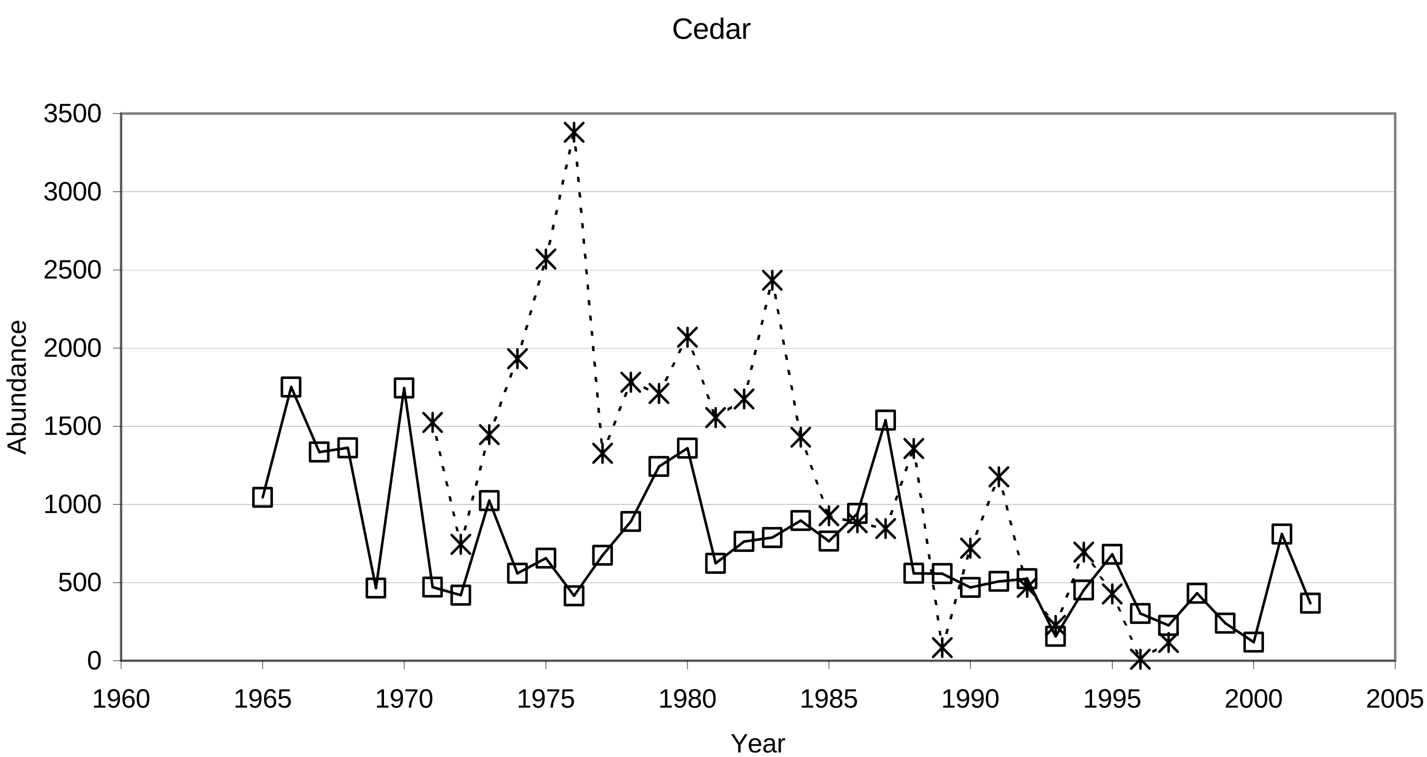
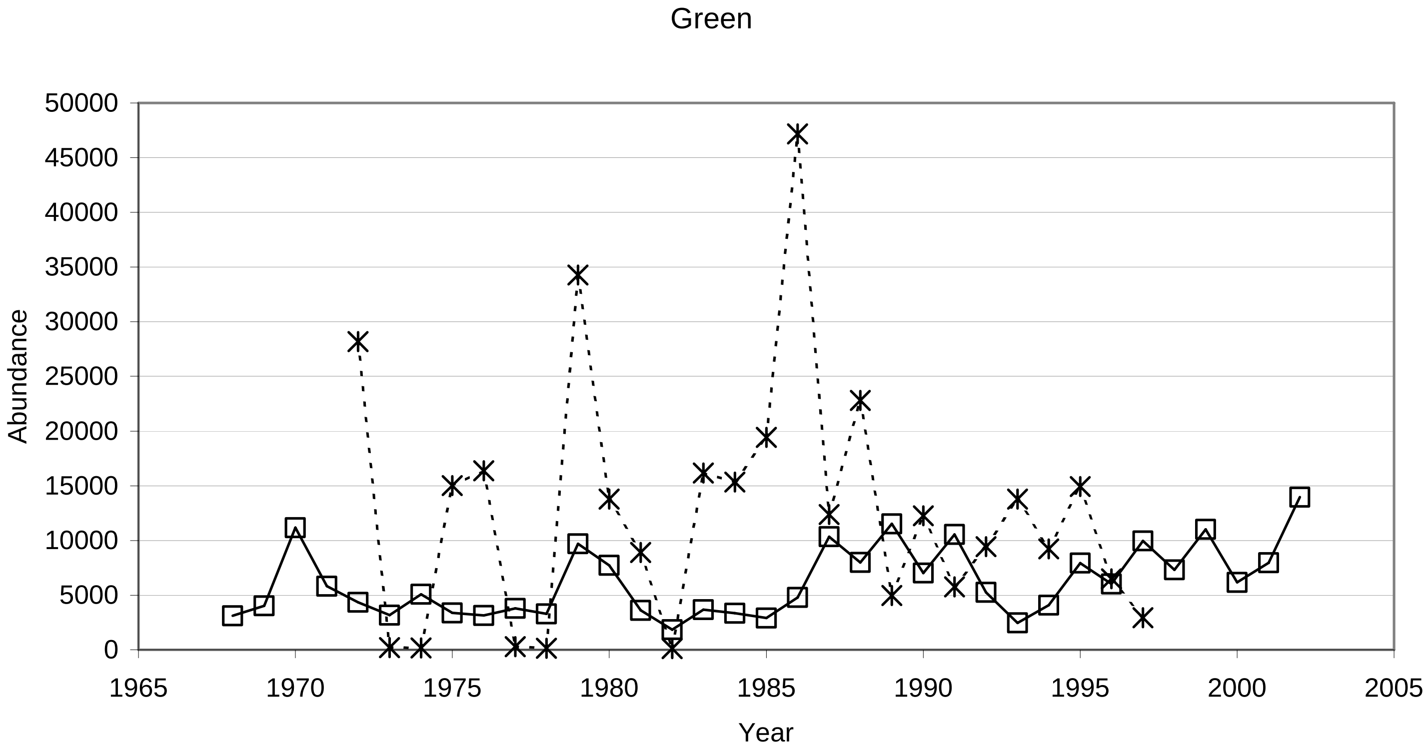


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



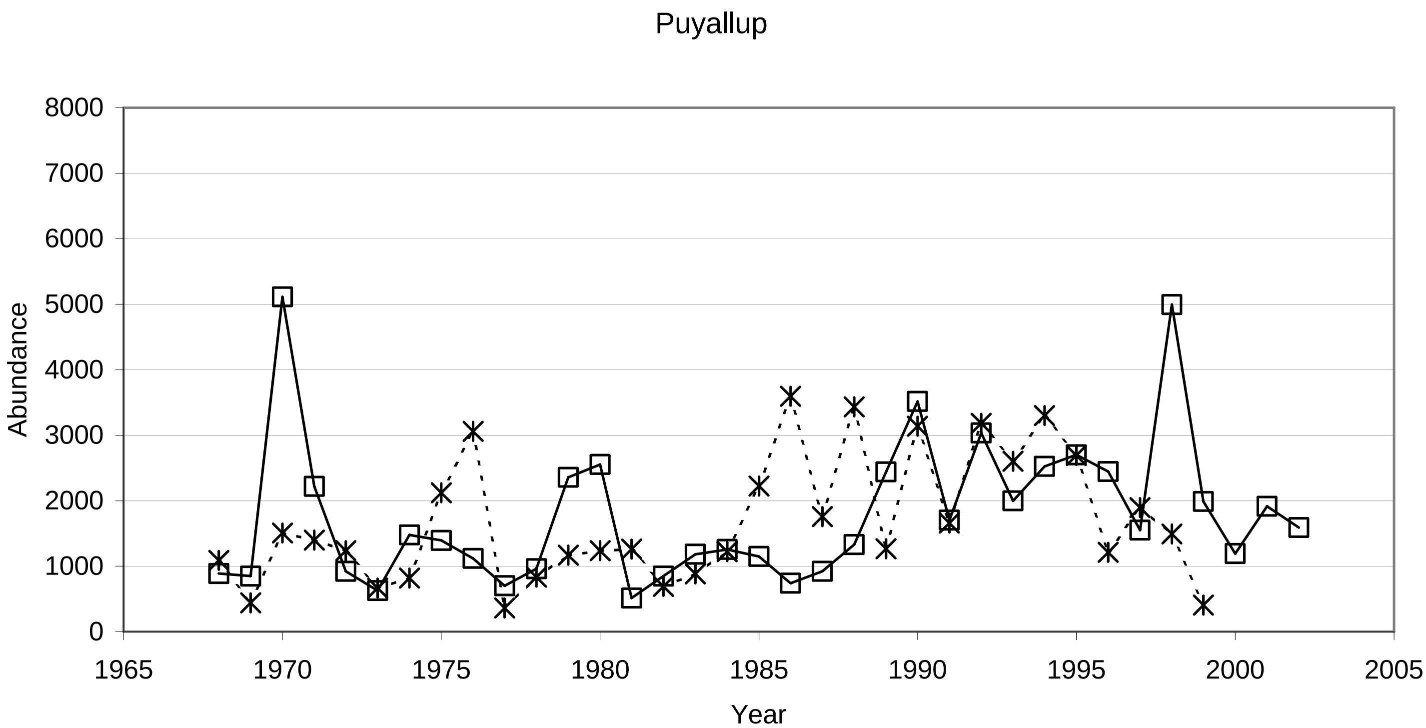
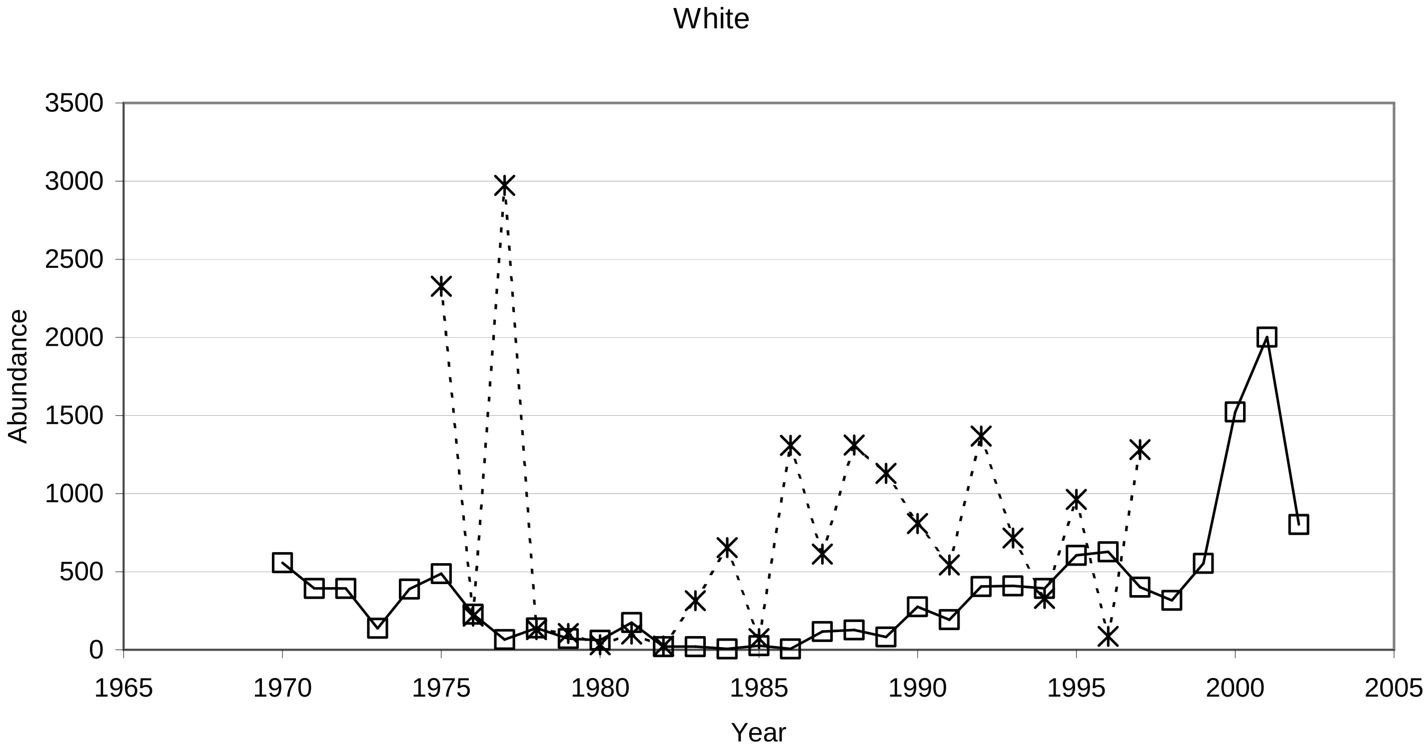


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



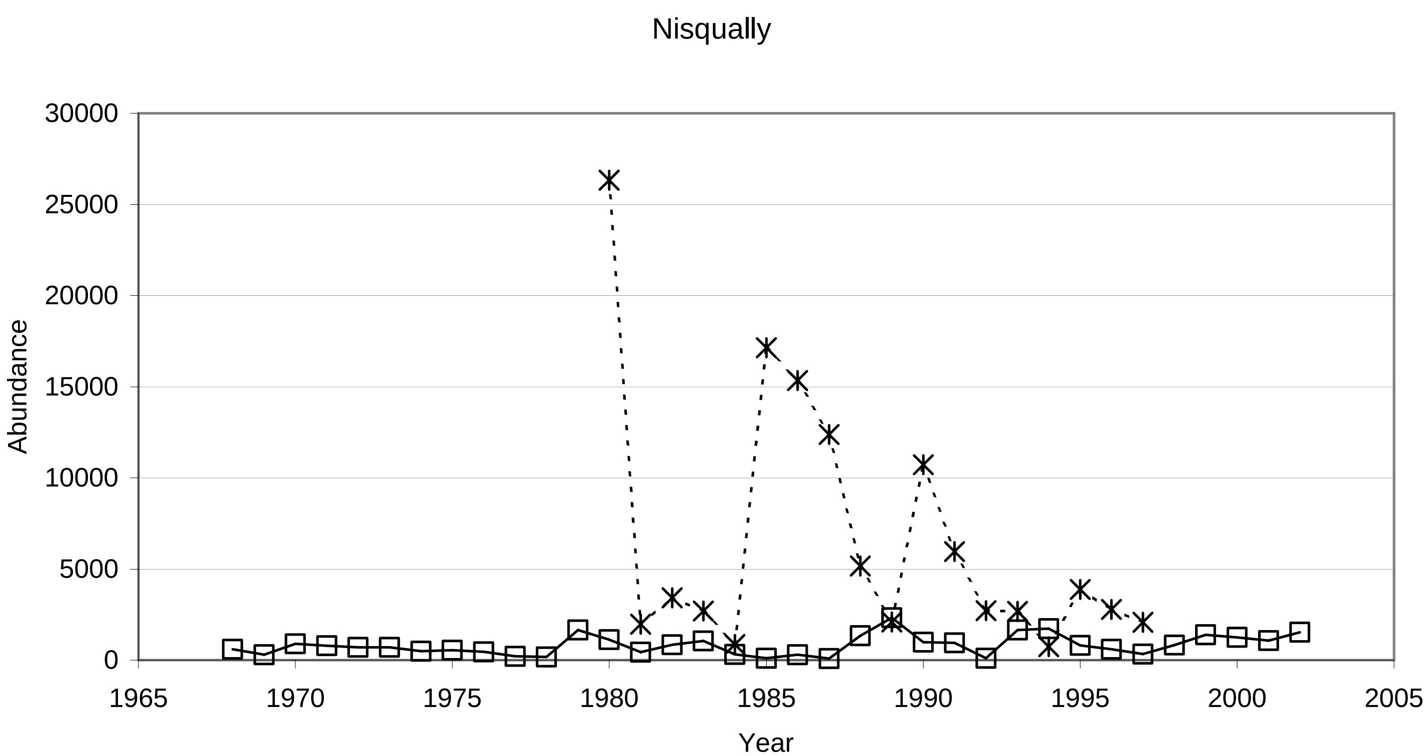
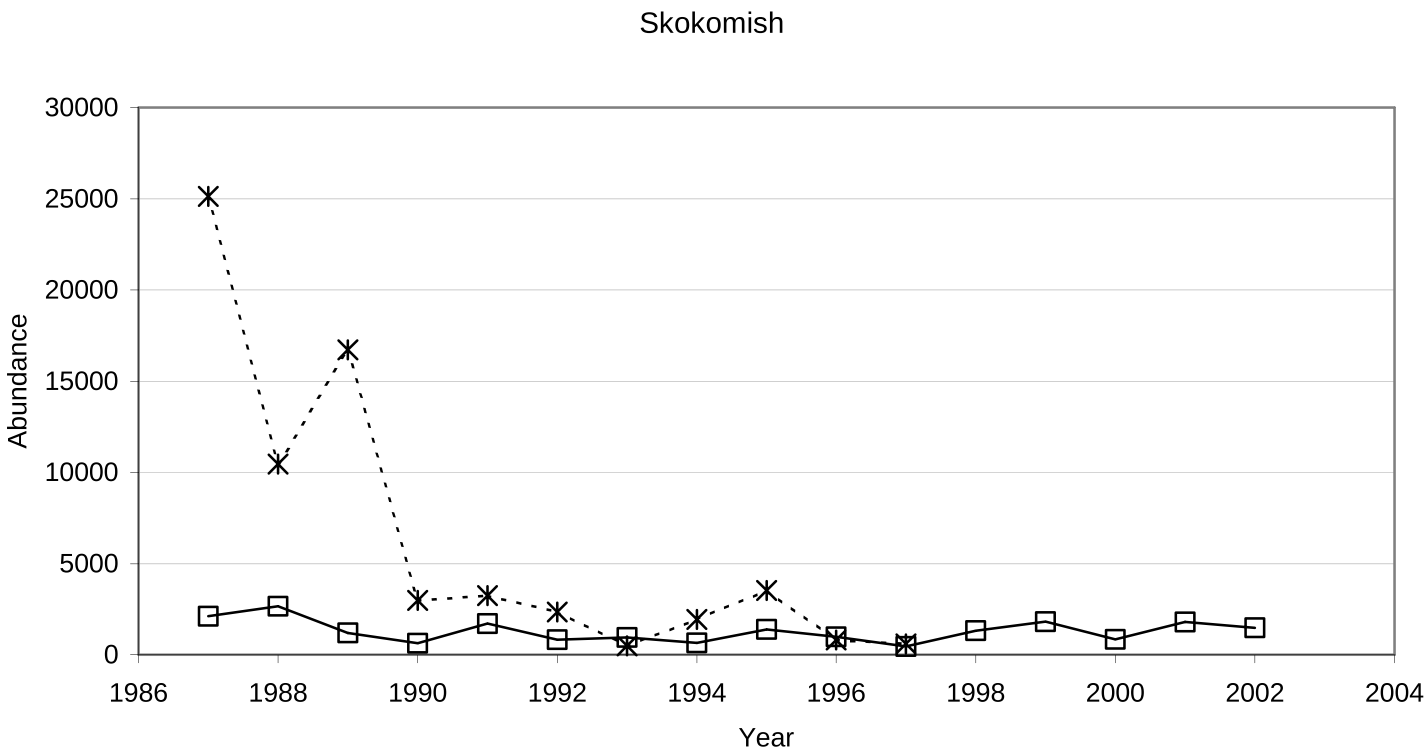


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



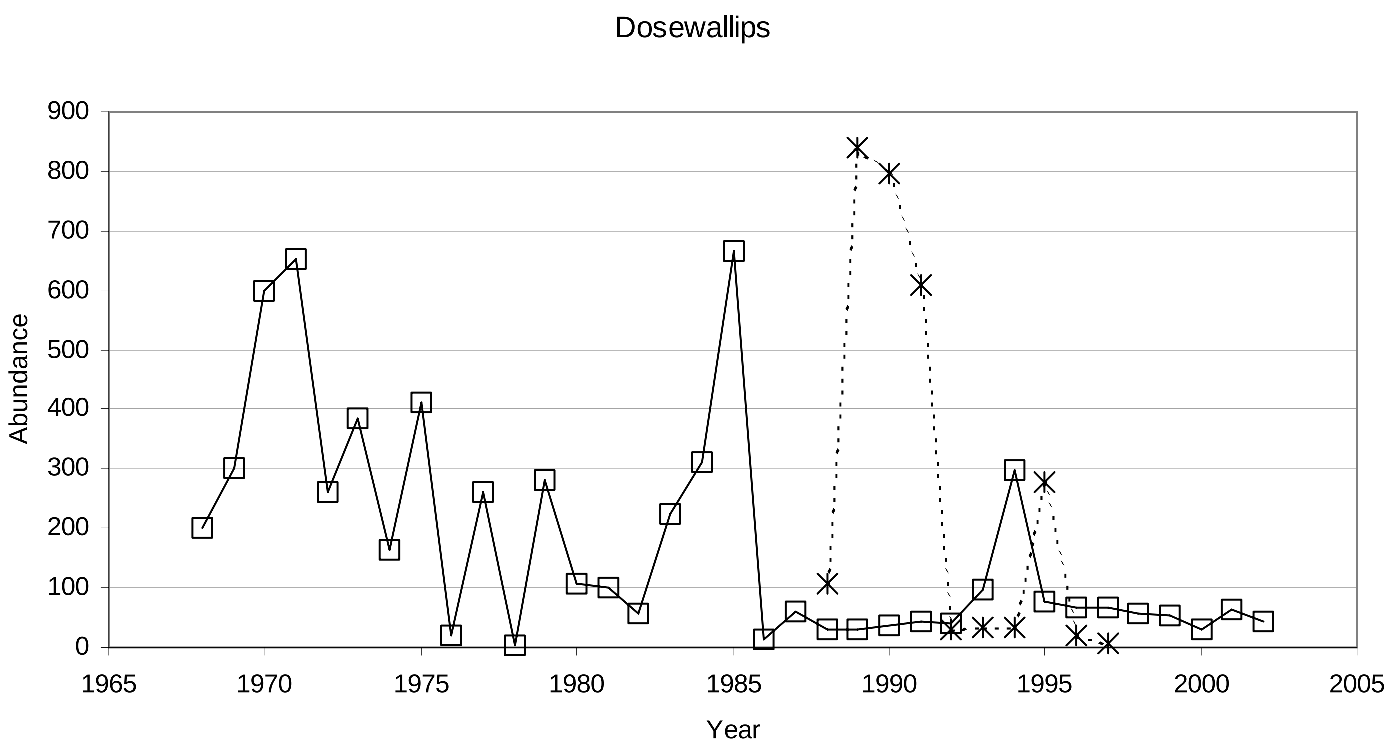
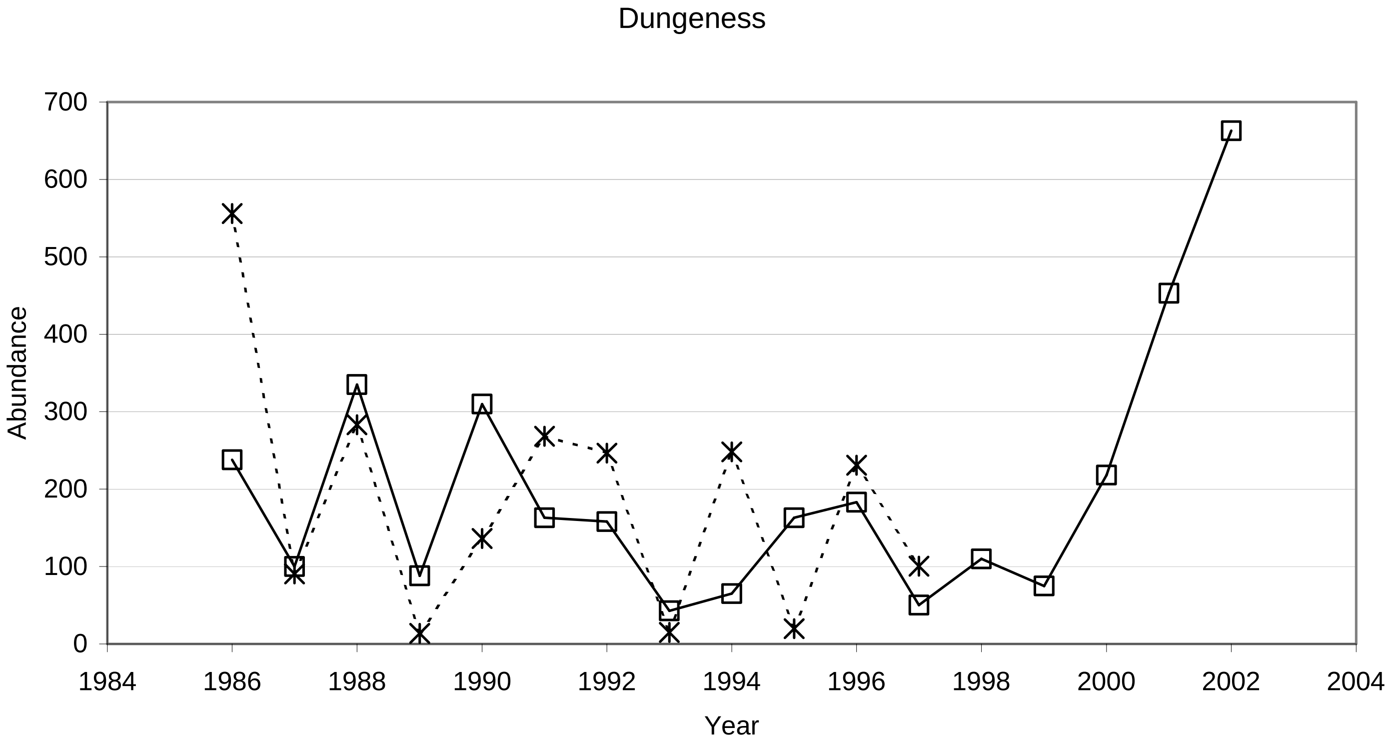
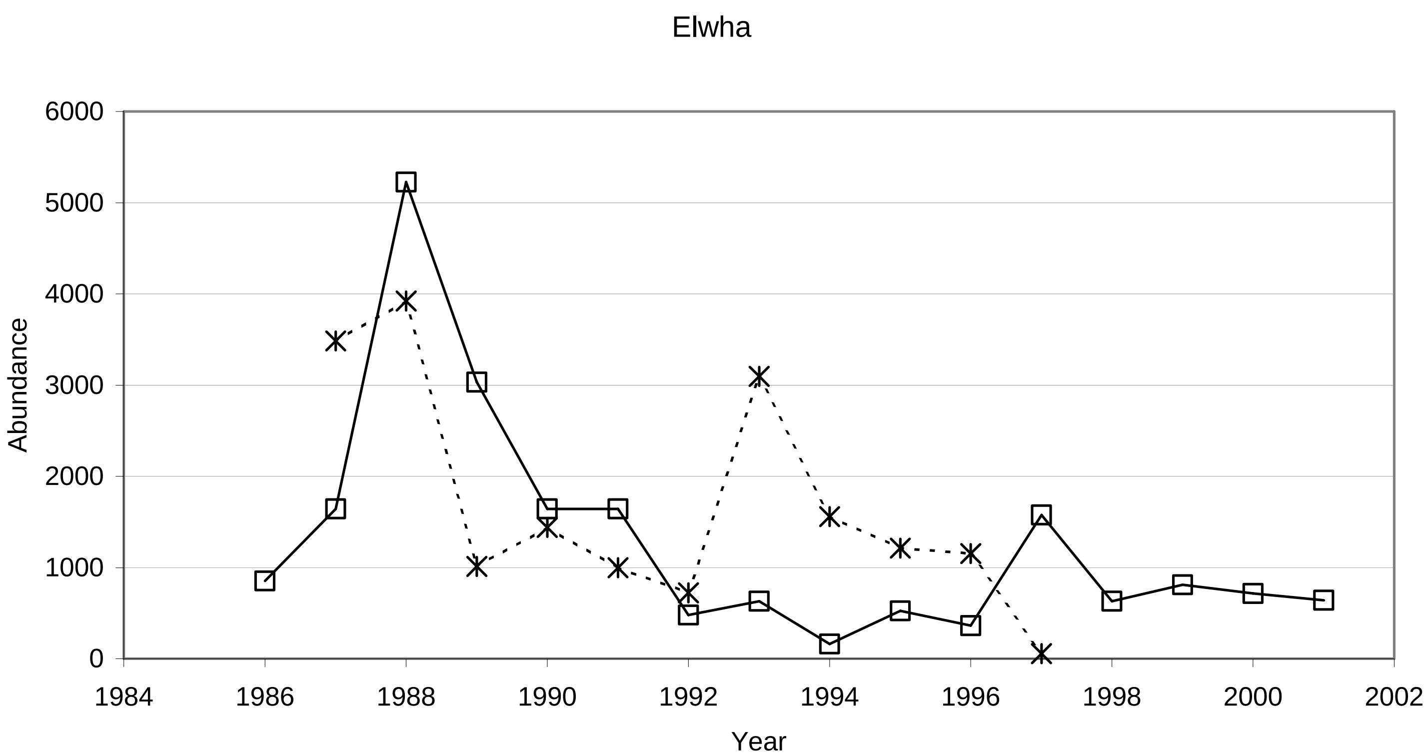


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)





A.2.5 LOWER COLUMBIA RIVER CHINOOK SALMON

A.2.5.1 Summary of Previous BRT Conclusions

The status of Lower Columbia River chinook was initially reviewed by NMFS in 1998 (Myers et al. 1998) and updated in that same year (NMFS 1998). In the 1998 update, the Biological Review Team (BRT) noted several concerns for this ESU. The 1998 BRT was concerned that there were very few naturally self-sustaining populations of native chinook salmon remaining in the Lower Columbia River ESU. Naturally reproducing (but not necessarily self-sustaining) populations identified by the 1998 BRT were the Lewis and Sandy Rivers "bright" fall runs and the "tule" fall runs in the Clackamas, East Fork Lewis and Coweeman Rivers. These populations were identified as the only bright spots in the ESU. The few remaining populations of spring chinook salmon in the ESU were not considered by the previous BRT to be naturally self-sustaining because of either small size, extensive hatchery influence, or both. The previous BRT felt that the dramatic declines and losses of spring-run chinook salmon populations in the Lower Columbia River ESU represented a serious reduction in life-history diversity in the region. The previous BRT felt that the presence of hatchery chinook salmon in this ESU posed an important threat to the persistence of the ESU and also obscured trends in abundance of native fish. The previous BRT noted that habitat degradation and loss due to extensive hydropower development projects, urbanization, logging and agriculture threatened the chinook salmon spawning and rearing habitat in the lower Columbia River. A majority of the previous (1998) BRT concluded that the Lower Columbia River ESU was likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.

Current Listing Status: threatened

A.2.5.2. New Data and Updated Analyses

New data acquired for this report includes spawner abundance estimates through 2001, new estimates of the fraction of hatchery spawners and harvest estimates. In addition, estimates of historical abundance have been provided by WDFW. Information on recent hatchery releases was also obtained. New analyses include the designation of relatively demographically independent populations, recalculation of previous BRT metrics with additional years data, estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish, and estimates of current and historically available kilometers of stream.

Historical population structure—As part of its effort to develop viability criteria for LCR chinook, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 20 fall-run populations ("tules"), two late fall-run populations ("brights") and nine spring-run populations for a total of 31 populations (Figures A.2.5.1 and A.2.5.2). The populations identified in Myers et al. are used as the units for the new analyses in this report.

The WLC-TRT partitioned LCR Chinook populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2003). The WLC-TRT concludes that a viable ESU would need multiple viable populations in each of these strata. The strata and associated populations are identified in Table A.2.5.1.

Table A.2.5.1. Historical population structure and abundance statistics for Lower Columbia River chinook populations. The populations are partitioned into ecological zones and major life history types. The ecological zones are based on ecological community and hydro-dynamic patterns and life history types are based on traits related to run timing. Time series used for the summary statistics are referenced in Appendix A.5.2. Natural-origin spawners had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery.

Life History	**Eco-logical Zone**	**Population**	**Years for Recent Means**	**Total Spawners**		**Natural-origin Spawners**		**Recent Average Hatchery-origin Spawners (%)**
				Recent Geometric Mean	**Recent Arithmetic Mean**	**Recent Geometric Mean**	**Recent Arithmetic Mean**	
Fall Run	Coastal	Youngs Bay Fall Run	No Data					
		Grays River Fall Run	1997-2001	99	152	59	89	38
		Big Creek Fall	No Data					
		Elochoman River Fall	1997-2001	676	1074	186	289	68
		Clatskanie River Fall	No Data					
		Mill, Aber., Germany Fall	1997-2001	734	1197	362	626	47
		Scappoose Creek Fall	No Data					
	Cascade	Coweeman Fall	1997-2001	274	469	274	469	0
		Lower Cowlitz Fall	1996-2000	1,562	1,626	463	634	62
		Upper Cowlitz Fall	2001	5,682				No Data (assumed high)
		Toutle River Fall	No Data					
		Kalama River Fall	1997-2001	2,931	3,138	655	1,214	67
		Salmon Crk/ Lewis Fall	1997-2001 (East Fork Data only	256	294	256	294	0

Life History	Eco-logical Zone	Population	Years for Recent Means	Total Spawners		Natural-origin Spawners		Recent Average Hatchery-origin Spawners (%)
				Recent Geometric Mean	Recent Arithmetic Mean	Recent Geometric Mean	Recent Arithmetic Mean	
		Clackamas River Fall	1998-2001	40	56	No Data		
		Washougal River Fall	1997-2001	3,254	3,364	1,130	1,277	58
		Sandy River Fall	1997-2001	183	216	No Data		
	Gorge	Lower Gorge Trib. Fall	No Data					
		Upper Gorge Trib. Fall	1997-2001 (Wind River Data only)	136	216	109	198	13
		Hood River Fall	1994-1998	18	21	No Data		
		Big White Salmon Fall	1997-2001	334	602	218	462	21
Late Fall (bright)	Cascade	Sandy Late Fall	1997-2001	504	773	778	750	3
		N.F. Lewis Late Fall (bright)	1997-2001	7,841	8,834	6,818	7,828	13
Spring Run	Cascade	Upper Cowlitz Spring	2001	1,787		No Data		
		Cispus River Spring						
		Tilton River Spring						
		Toutle River Spring	No Data					
		Kalama River Spring	1997-2001	98	185	No Data		
		Lewis River Spring	1997-2001	347	363	No Data		
		Sandy River Spring	No Data					
	gorge	Big White Salmon Spring	No Data (No fish?)					
		Hood River Spring	1994-1998	51	61	No data		

Abundance and trends

Data sources for abundance time series and related data are in Appendix A.5.2. The recent abundance of both total and natural-origin spawners, and recent fraction of hatchery-origin spawners for LoCR Chinook populations are summarized in Table A.2.5.1. Natural-origin fish had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery. The abundances of natural-origin spawners range from near extirpation for most of the spring run populations to over 7,841 for the Lewis River bright population. The majority of the fall-run tule populations have a substantial fraction of hatchery-origin spawners in the spawning areas and may be sustained largely by hatchery production. Exceptions are the Coweeman population and the East Fork Lewis portion of the Lewis River/Salmon Creek population, which have few hatchery fish spawning on the natural spawning areas. These two populations have recent geometric mean natural-origin abundance estimates of 274 and 256 spawners respectively. Although quantitative information is not yet available, preliminary examination of scales indicates that almost all current spring run spawners in the Washington part of this ESU are of hatchery origin (Rawding, pers. comm.) The majority of the spring run populations have been extirpated largely as the result of dams blocking access to their high elevation habitat. The two bright chinook populations (i.e., Lewis and Sandy) have relatively high abundances, particularly the Lewis.

Access to the habitat of the historical Upper Cowlitz, Cispus, and Tilton Rivers populations is blocked by the Mayfield, Mossy Rock and Cowlitz Falls dams. A relatively large number of both spring and fall Chinook are currently released as part of a reintroduction program to establish chinook above Cowlitz Falls dam (Serl and Morrill 2002). The adults for the reintroduction program are collected at the Cowlitz Salmon hatchery and the vast majority of the chinook trucked above Cowlitz Falls are believed to be of hatchery origin, though marking of hatchery fish is not complete and a quantitative assessment has not been undertaken. Downstream survival of juvenile chinook though the dams and reservoirs is considered negligible, so juveniles are collected at Cowlitz Falls and trucked downstream. The current collection efficiency of juveniles at Cowlitz Falls is considered too low for the reintroduction to be self-sustaining (Rawding 2003 pers. comm.).

Where data are available, the abundance time series information for each of the populations is presented in Figures A.2.5.3-A.2.5.30. Three types of time series figures are presented. The first type of figure plots abundance against time (Figures A.2.5.3, A.2.5.4, A.2.5.5, A.2.5.6, A.2.5.8, A.2.5.10, A.2.5.12, A.2.5.14, A.2.5.16, A.2.5.18, A.2.5.20, A.2.5.21, A.2.5.22, A.2.5.24, A.2.5.25, A.2.5.26, and A.2.5.27). Where possible, two lines are presented on the abundance figure, where one line is the estimated total number of spawners and the other line is the estimated number of fish of natural origin. In many cases, data were not available to distinguish between natural- and hatchery-origin spawners, so only total spawner information is presented. This type of figure can give a sense of the levels of abundance, overall trend, patterns of variability, and the fraction of hatchery-origin spawners. A high fraction of hatchery-origin spawners indicates that the population may potentially be sustained by hatchery production and not the natural environment. It is important to note that estimates of the fraction of hatchery-origin fish are highly uncertain since the hatchery marking rate for LCR fall chinook is generally only a few percent and expansion to population hatchery fraction is based on only a handful of recovered marked fish (unpublished analysis, McElhany, Rawding, and Sydor). The second type of time series figure displays fish per mile data. For three populations of fall run chinook in Oregon watersheds, total abundance estimates are not available, but fish per mile time series exists (Figures A.2.5.28-A.2.5.30). There are no estimates of the fraction of hatchery-origin spawners in these fish/mile time series, but the percentage may be high given the large number of hatchery fish released and the high fraction of hatchery-origin spawners estimated in Washington watersheds directly across the Columbia River. The lack of information on hatchery fraction reduces the value of these time series for evaluating extinction risk.

The third type of time series figure presents the total number of spawners (natural and hatchery origin) and the estimated number of preharvest recruits produced by those spawners against time (Figures A.2.5.7, A.2.5.7.9, A.2.5.7.11, A.2.5.13, A.2.5.15, A.2.5.17, A.2.5.19, A.2.5.23). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner for the broodyear. Spawner are taken as the sum of hatchery and natural-origin spawners. This type of figure requires harvest and age structure information and therefore could be produced for only a limited number of populations. This type of figure can indicate whether there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest.

Summary statistics on population trends and growth rate are presented in Tables A.2.5.2-A.2.5.4. The methods for estimating trends and growth rate (λ) are described in the general method section. Trends are calculated on total spawners, both hatchery and natural origin. The λ estimate is calculated under two different assumptions about the reproductive success of hatchery-origin spawners. In one analysis, hatchery-origin spawner are assumed to have zero reproductive success and in the other analysis, hatchery-origin spawners are assumed to have a reproductive success equal to that of natural-origin spawners. Because λ is only calculated for time series where the fraction of hatchery-origin spawners is known, most of the long-term trend estimates use data starting in 1980, even though the abundance time series of total spawners may extend earlier than 1980. The majority of populations have a long-term trend less than one, indicating the population is in decline. In addition, there is a high probability for most populations that the true trend/growth rate is less than one (Table A.2.5.4). However, in general there is a great deal of uncertainty about the growth rate, as indicated by the large confidence intervals. The uncertainly about growth rate is generally higher for chinook than for other LCR anadromous salmonids because of the high variability observed in the time series. A negative long-term growth rate is indicated for all of the populations except the Coweeman fall run when analyzed under the assumption that hatchery-origin fish have a reproductive success equal to natural-origin fish. The Coweeman fall run had very few hatchery-origin spawners (Table A.2.5.2). The potential reasons for these declines have been cataloged in previous status reviews and include habitat degradation, overharvest, deleterious hatchery practices, and climate-driven changes in marine survival.

The Lewis River bright population is considered the healthiest in the ESU. The population is significantly larger than any other population in the ESU, and, in fact, it is larger than any population of salmon in the Columbia Basin except the Hanford Reach chinook. The

Lewis bright chinook harvest has been managed to an escapement target of 5,700 and this target has been met every year for which data are available except 1999 (Figure A.2.5.16). The preharvest recruits have exceeded spawners in all years for which data are available except two (Figure A.2.5.17). There has been a hatchery program for Lewis River brights, but hatchery-origin spawners have generally comprised less than 10% of the spawning population over the time series. These indicators all suggest a relatively healthy population. However, the long-term population trend estimate is negative (Figure A.2.5.30), and it is not clear the extent to which this reflects management decisions to harvest closer to the escapement goal as compared to declining productivity over the time series. The population is also geographically confined to a reach that is only a few kilometers in length and is immediately below Merwin Dam, where it is affected by the flow management of the hydrosystem. This limited spatial distribution is a potential risk factor.

Table A.2.5.2.. Long-term trend and growth rate for subset of Lower Columbia chinook populations for which adequate data are available (95% C.I. are in parentheses). The long-term analysis used the entire data set. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In “Hatchery = 0” columns, hatchery fish are assumed to have zero reproductive success. In the “Hatchery = Wild” columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Long-term Trend**	**Long-term Trend of Total Spawners**	**Years for Long-term λ**	**Long-term Median Growth Rate (λ)**	
					Hatchery = 0	**Hatchery = Wild**
Fall	Grays River fall-run	1964-2001	0.965 (0.928-1.003)	1980-2001	0.944 (0.739-1.204)	0.844 (0.660-1.081)
	Elochoman River fall-run	1964-2001	1.019 (0.990-1.048)	1980-2001	1.037 (0.813-1.323)	0.800 (0.625-1.024)
	Mill, Abernathy, Germany Creekd fall-run	1980-2001	0.965 (0.909-1.024)	1980-2001	0.981 (0.769-1.252)	0.829 (0.648-1.006)
	Coweeman River fall-run	1964-2001	1.046 (1.018-1.075)	1980-2001	1.092 (0.855-1.393)	1.091 (0.852-1.396)
	Lower Cowlitz River fall-run	1964-2000	0.951 (0.933-0.968)	1980-2000	0.998 (0.776-1.282)	0.682 (0.529-0.879)
	Kalama River fall-run	1964-2001	0.994 (0.973-1.016)	1980-2001	0.973 (0.763-1.242)	0.818 (0.639-1.048)
	Salmon Creek/ Lewis River fall-run	1980-2001	0.981 (0.949-1.014)	1980-2001	0.984 (0.771-1.256)	0.979 (0.765-1.254)
	Clackamas River fall-run	1967-2001	0.937 (0.910-0.965)	No Hatchery Fraction Data		

	Washougal River fall-run	1964-2001	1.088 (1.002-1.115)	1980-2001	1.025 (0.803-1.308)	0.815 (0.637-1.045)
	Upper Gorge Tributaries fall-run	1964-2001 (Wind only)	0.935 (0.892-0.979)	1980-2001	0.959 (0.751-1.224)	0.955 (0.746-1.223)
	Big White Salmon River fall-run	1967-2001	0.941 (0.912-0.971)	1980-2001	0.963 (0.755-1.229)	0.945 (0.738-1.210)
Late Fall Run (brights)	Sandy River late fall-run	1984-2001	0.946 (0.880-1.014)	1984-2001	0.943 (0.715-1.243)	0.935 (0.706-1.237)
	North Fork Lewis River late fall-run	1964-2001	0.992 (0.980-1.008)	1980-2001	0.968 (0.756-1.204)	0.948 (0.741-1.214)
Spring Run	Upper Cowlitz River spring-run	1980-2001	0.994 (0.942-1.064)	No Hatchery Fraction Data (presumed high)		
	Kalama River spring-run	1980-2001	0.945 (0.840-1.064)	No Hatchery Fraction Data (presumed high)		
	Lewis River spring-run	1980-2001	0.935 (0.879-0.995)	No Hatchery Fraction Data (presumed high)		

Table A.2.5.3. Short-term trend and growth rate for subset of Lower Columbia chinook populations for which adequate data are available (95% C.I. are in parentheses). Short-term data sets include data from 1990 to the most recent available year. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Short-term Trend**	**Short-term Trend of Total Spawners**	**Years for Short-term λ**	**Short-term Median Growth Rate (λ)**	
					Hatchery = 0	**Hatchery = Wild**
Fall	Grays River fall-run	1990-2001	1.086 (0.840-1.405)	1990-2001	1.004 (0.787-1.282)	0.898 (0.701-1.150)
	Elochoman River fall-run	1990-2001	1.154 (0.988-1.347)	1990-2001	1.119 (0.877-1.428)	0.869 (0.679-1.113)
	Mill, Abernathy, Germany Creeks fall-run	1990-2001	0.974 (0.833-1.139)	1990-2001	0.993 (0.778-1.268)	0.823 (0.643-1.054)
	Coweeman River fall-run	1990-2001	0.985 (0.816-1.139)	1990-2001	0.977 (0.765-1.247)	0.977 (0.763-1.251)
	Lower Cowlitz River fall-run	1990-2000	1.031 (0.969-1.097)	1990-2000	1.231 (0.873-1.443)	0.782 (0.607-1.009)

	Kalama River fall-run	1990-2001	0.996 (0.898-1.104)	1990-2001	0.944 (0.740-1.205)	0.799 (0.624-1.022)
	Salmon Creek/ Lewis River fall-run	1990-2001	1.017 (0.929-1.114)	1990-2001	1.027 (0.805-1.311)	1.027 (0.802-1.315)
	Clackamas River fall-run	1990-2001	0.799 (0.677-0.945)	1990-2001	No Hatchery Fraction Data	
	Washougal River fall-run	1990-2001	1.009 (0.961-1.058)	1990-2001	0.985 (0.722-1.257)	0.769 (0.600-0.989)
	Upper Gorge Tributaries fall-run	1990-2001	1.291 (0.943-1.769)	1990-2001	1.246 (0.976-1.590)	1.235 (0.964-1.581)
	Big White Salmon River fall-run	1990-2001	1.106 (0.899-1.361)	1990-2001	1.057 (0.828-1.348)	1.013 (0.791-1.297)
Late Fall Run (brights)	Sandy River late fall-run	1990-2001	0.915 (0.796-1.052)	1990-2001	0.919 (0.697-1.212)	0.912 (0.689-1.207)
	North Fork Lewis River late fall-run	1990-2001	0.969 (0.889-1.056)	1990-2001	0.966 (0.754-1.236)	0.945 (0.738-1.210)
Spring Run	Upper Cowlitz River spring-run	1990-2001	1.011 (0.891-1.148)	1990-2001	No Hatchery Fraction Data	
	Kalama River spring-run	1990-2001	1.080 (0.880-1.326)	1990-2001	No Hatchery Fraction Data	
	Lewis River spring-run	1990-2001	0.857 (0.783-0.937)	1990-2001	No Hatchery Fraction Data	

Table A.2.5.4. Probability that the long-term abundance trend or growth rate of as subset of Lower Columbia River steelhead populations is less than one. In the “Hatchery = 0” columns, the hatchery-origin fish are assumed to have zero reproductive success. In the “Hatchery = Wild” columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	**Population**	**Long –Term Analysis**			**Short-Term Analysis**		
		Prob. Trend <1	**Prob. λ <1**		**Prob. Trend <1**	**Prob. λ <1**	
			Hatchery =0	**Prob. Trend <1**		**Hatchery =0**	**Hatchery = Wild**
Fall Run	Grays River fall-run	0.965	0.715	0.947	0.245	0.491	0.710
	Elochoman River fall-run	0.099	0.373	0.967	0.033	0.270	0.765
	Mill, Abernathey, Germany Creeks fall-run	0.887	0.581	0.973	0.643	0.514	0.833
	Coweeman River fall-run	0.001	0.194	0.196	0.570	0.556	0.556
	Lower Cowlitz River fall-run	1.000	0.510	0.510	0.148	0.216	0.952

	Kalama River fall-run	0.710	0.612	0.612	0.536	0.704	0.962
	Salmon Creek/ Lewis River fall-run	0.876	0.663	0.663	0.340	0.331	0.331
	Clackamas River fall-run	1.000	No hatchery fraction data		0.993	No hatchery fraction data	
	Washougal River fall-run	0.000	0.323	0.323	0.350	0.556	0.989
	Upper Gorge Tributaries fall-run	0.997	0.612	0.612	0.050	0.137	0.148
	Big White Salmon River fall-run	1.000	0.623	0.623	0.151	0.405	0.476
Late Fall Run (brights)	Sandy River late fall-run	0.994	0.833	0.833	0.906	0.828	0.849
	North Fork Lewis River late fall-run	0.817	0.800	0.800	0.785	0.733	0.841
Spring Run	Upper Cowlitz River spring-run	0.591	No hatchery fraction data		0.423	No hatchery fraction data	
	Kalama River spring-run	0.834	No hatchery fraction data		0.210	No hatchery fraction data	
	Lewis River spring-run	0.993	No hatchery fraction data		0.998	No hatchery fraction data	

Ecosystem Diagnosis and Treatment (EDT) based estimates of historical abundance

The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of the Lower Columbia River chinook populations using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). The EDT model attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/ dungenesswc/EDT-primer.pdf). WDFW populated this model with estimates of historical habitat condition that produced the estimates of average historical abundance shown in Table A.2.5.5. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates that should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas are historically accessible but currently blocked by large dams are omitted from the analyses, and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Table A.2.5.5. Estimate of historical abundance based on EDT analysis by WDFW of equilibrium abundance under historical habitat conditions (Busack and Rawding 2003).

Population	EDT Estimate of Historical Abundance
Grays River fall-run	2,477
Coweeman River fall-run	4,971
Lower Cowlitz River fall--run	53,956
Toutle River fall-run	25,392
Kalama River fall-run	2,455
Lewis River fall-run (East Fork only)	4,220
Lewis River late fall-run (brights)	43,371
Washougal River fall-run	7,518
Upper Gorge Tributaries fall-run (Wind River only)	2,363
Toutle River spring-run	2,901
Kalama River spring-run	4,178

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the LCR (Table A.2.5.6). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream kilometers as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations (particularly spring run) the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table A.2.5.6.. Loss of habitat from barriers. The potential current habitat is the kilometers of stream with a gradient between 0.5% and 4% below all currently impassable barriers. The potential historical habitat is the kilometers of stream with a gradient of between 0.5% and 4% below historically impassable barriers. The current to historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio (%)
Youngs Bay fall-run	178	195	91
Grays River fall-run	133	133	100
Big Creek fall-run	92	129	71
Elochoman River fall-run	85	116	74
Clatskanie River fall-run	159	159	100
Mill, Abernathy, Germany Creeks fall-run	117	123	96
Scappoose Creek fall-run	122	157	78
Coweeman River fall-run	61	71	86
Lower Cowlitz River fall-run	418	919	45
Upper Cowlitz River fall-run			
Toutle River fall-run	217	313	69

Kalama River fall-run	78	83	94
Salmon Creek/Lewis River fall-run	438	598	73
Clackamas River fall-run	568	613	93
Washougal River fall-run	84	164	51
Sandy River fall-run	227	286	79
Lower Gorge Tributaries fall-run	34	35	99
Upper Gorge Tributaries fall-run	23	27	84
Hood River fall-run	35	35	100
Big White Salmon River fall-run	0	71	0
Sandy River late fall-run	217	225	96
North Fork Lewis River late fall-run (brights)	87	166	52
Upper Cowlitz spring-run	4	276	1
Cispus River spring-run	0	76	0
Tilton River spring-run	0	93	0
Toutle River spring-run	217	313	69
Kalama River spring-run	78	83	94
Lewis River spring-run	87	365	24
Sandy River spring-run	167	218	77
Big White Salmon River spring-run	0	232	0
Hood River spring-run	150	150	99
Total	4,075	6,421	63

A.2.5.4 New Hatchery Information

Recent Hatchery Releases

Updated information on chinook hatchery releases in the ESU is provided in Appendix A.5.3. These data indicate a high level of chinook hatchery production in the LCR. Categorizations of Lower Columbia River hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.5.5 Comparison with Previous Data

ESU Summary

The ESU exhibits three major life history types: fall run (“tules”), late fall run (“brights”), and spring run. The ESU spans three ecological zones: Coastal (rain driven hydrograph), Western Cascade (snow or glacial driven hydrograph), and Gorge (transitioning to drier interior Columbia ecological zones). The fall chinook populations are currently dominated by large scale hatchery production, relatively high harvest and extensive habitat degradation (discussed in previous status reviews). The Lewis River late fall chinook population is the healthiest in the ESU and has a reasonable probability of being self-sustaining. The spring-run populations are largely extirpated as the result of dams which block access to their high elevation habitat. Abundances have largely declined since the last status review update (1998) and trend indicators for most populations are negative, especially if hatchery fish are assumed to have a reproductive success equivalent to that of natural-origin fish. However, 2001 abundance estimates increased for most LCR chinook populations over the previous few years and preliminary indications are that 2002 abundance also increased (Rawding, WDFW pers. com.). Many salmon populations in the Northwest have shown increases in abundance over the last few years and the relationship of these increases to potential changes in marine survival are discussed in the introduction to this report.

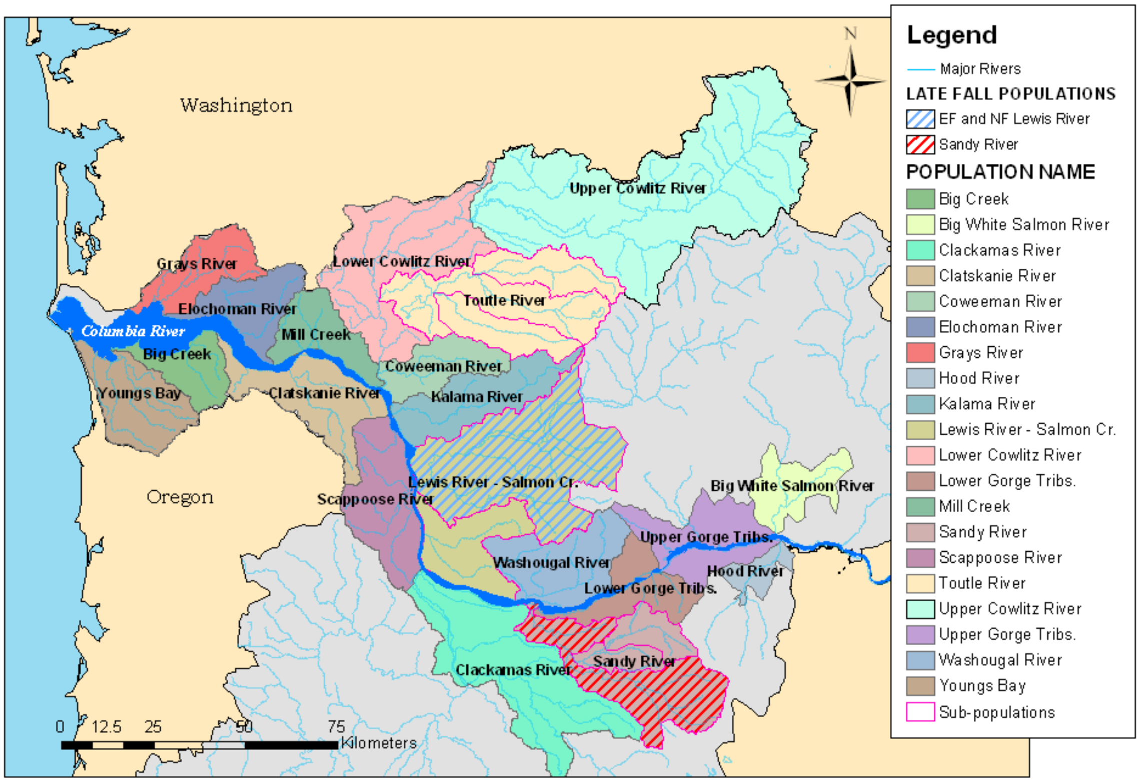


Figure A.2.5.1. Historical independent LCR early and late fall Chinook populations (Myers et al. 2002).

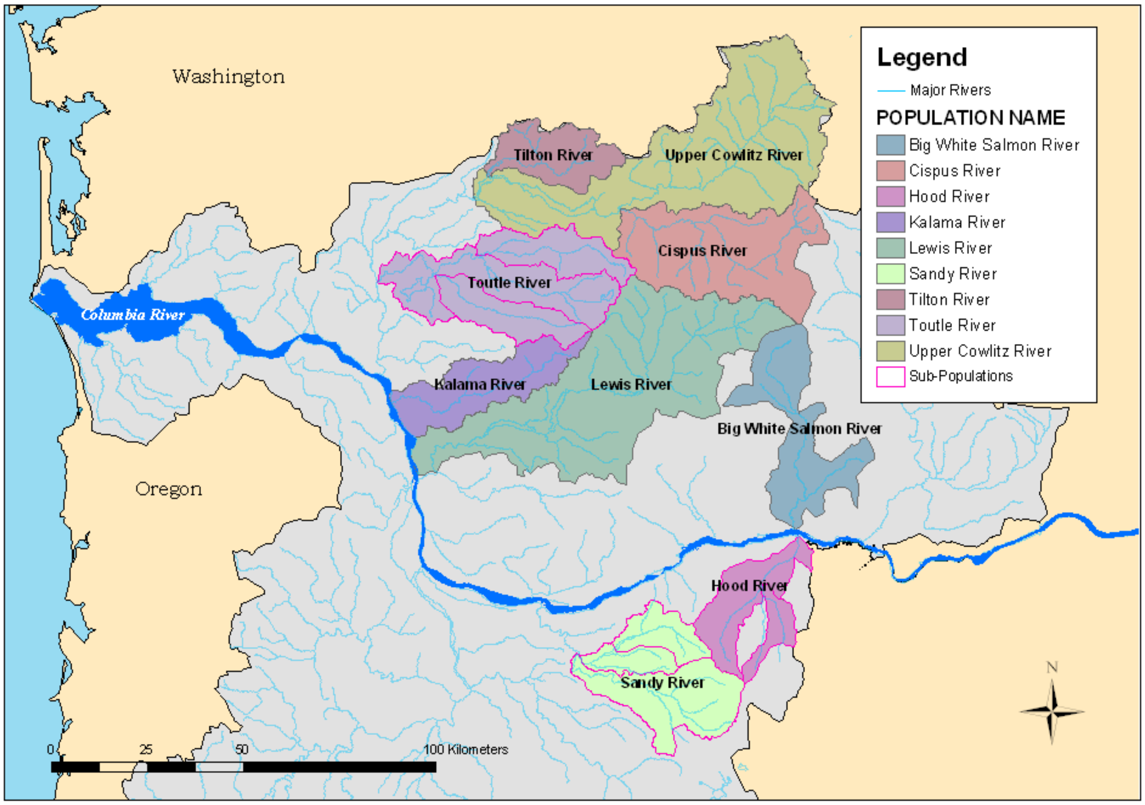


Figure A.2.5.2. Historical independent LCR spring Chinook populations (Myers et al. 2002).

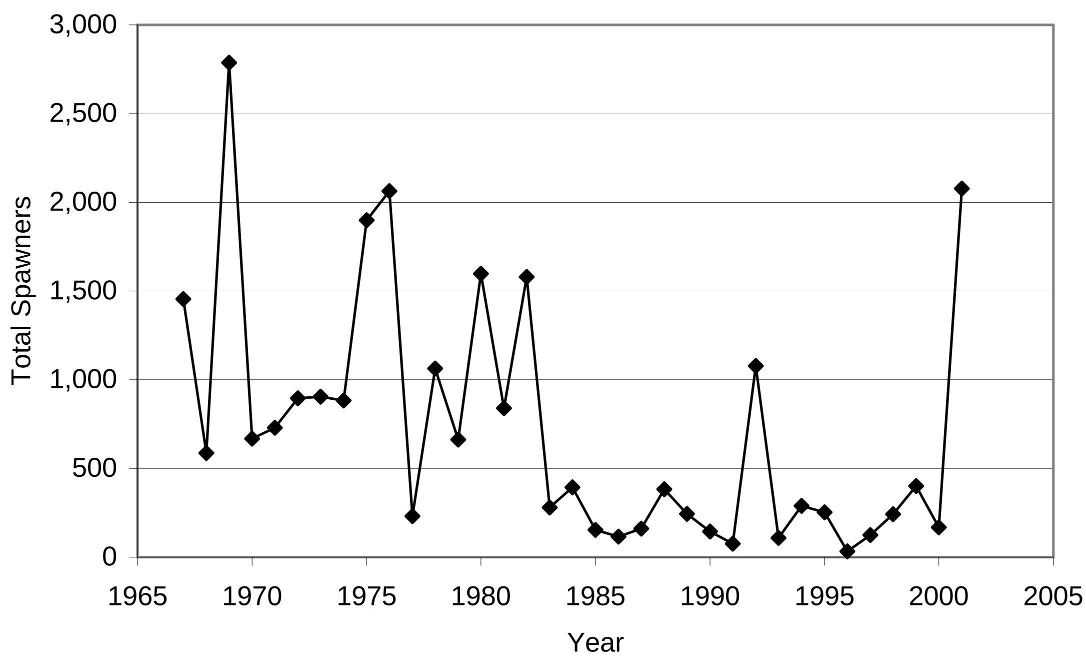


Figure A.2.5.3. Big White Salmon River fall-run chinook spawner abundance (hatchery and natural-origin).

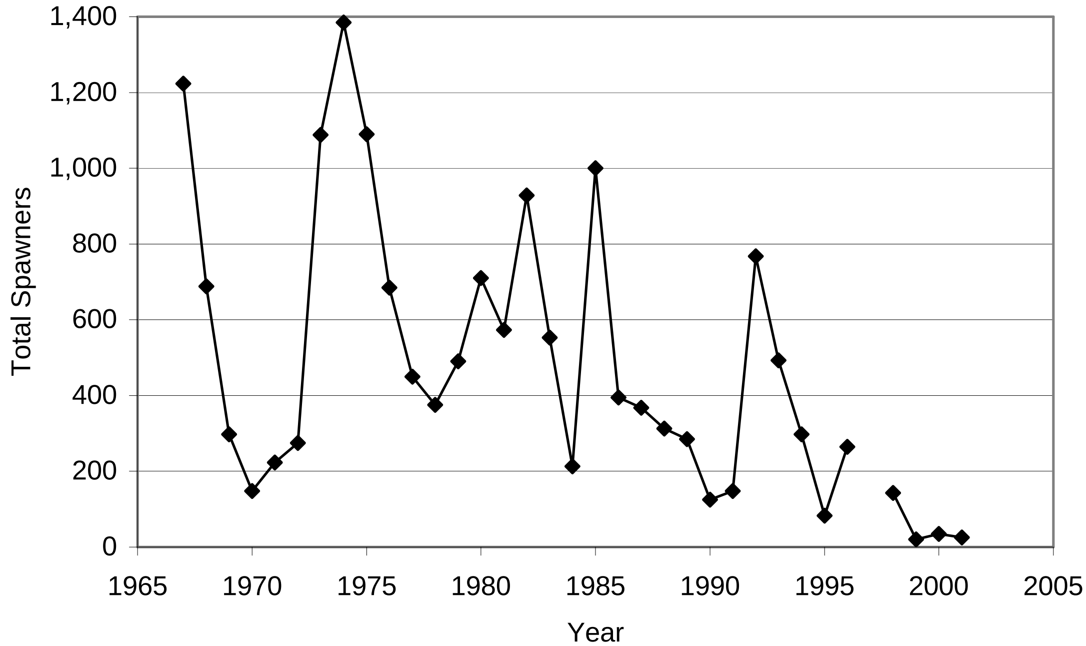


Figure A.2.5.4. Clackamas River fall-run chinook spawner abundance (hatchery and natural origin).

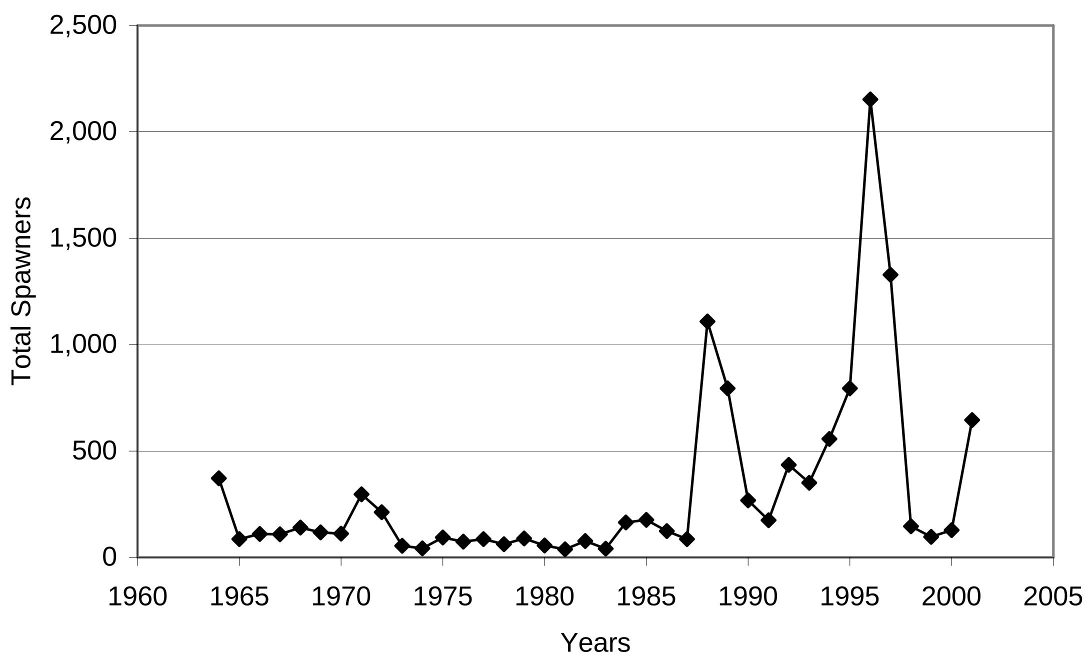


Figure A.2.5.5. Coweeman River fall-run chinook spawner abundance (almost all spawners are of natural origin).

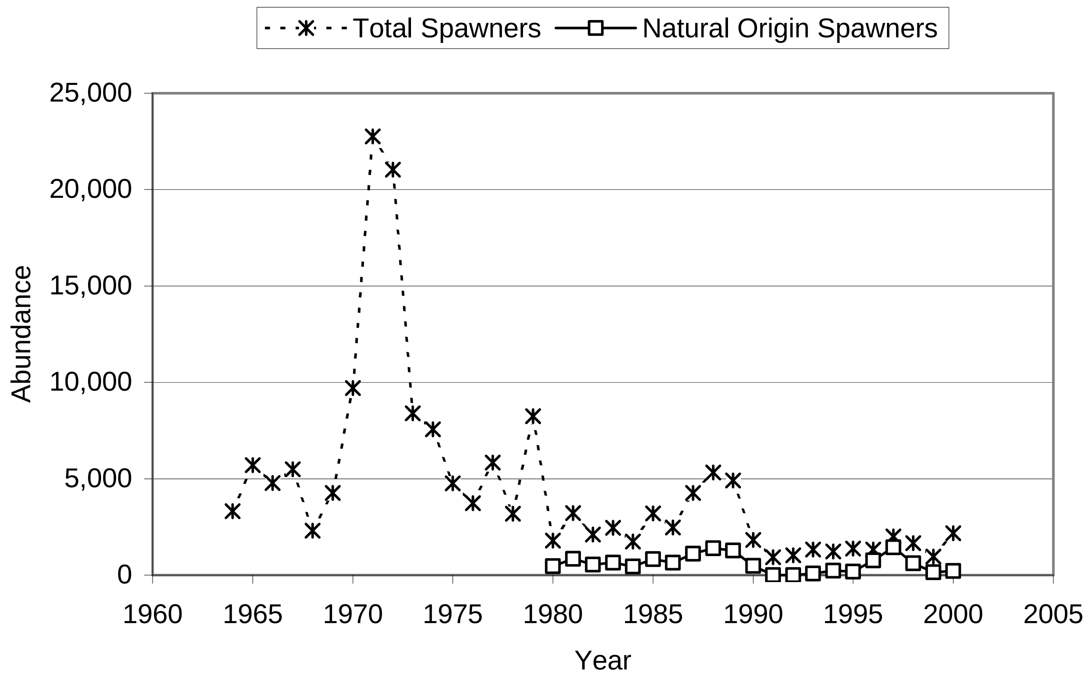


Figure A.2.5.6. Lower Cowlitz River fall-run chinook spawner abundance.

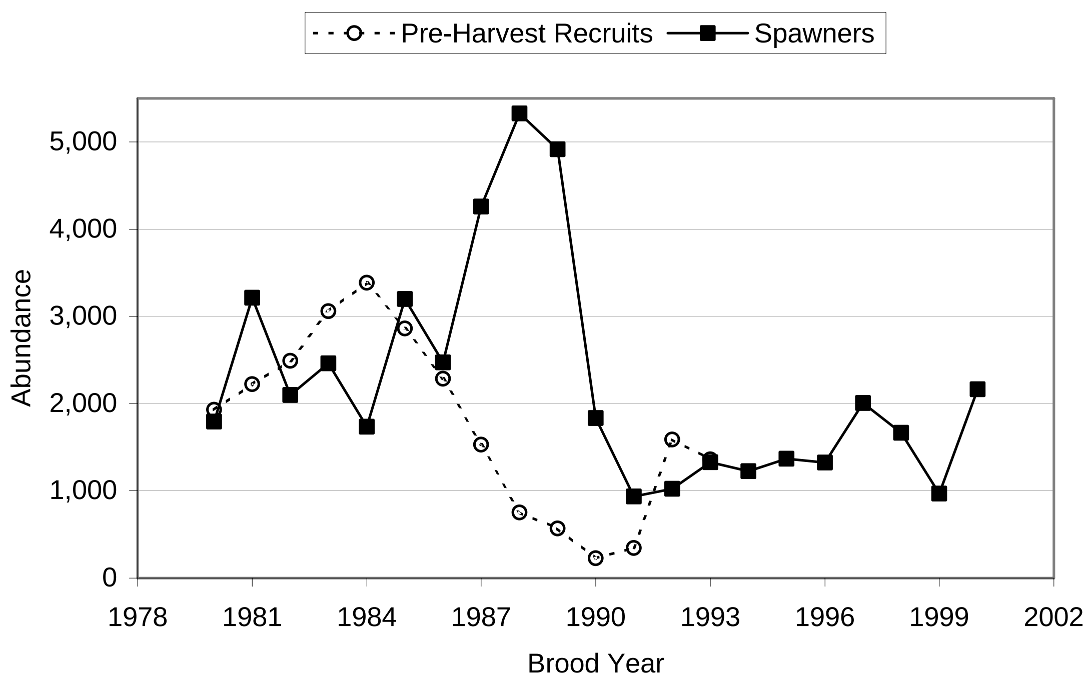


Figure A.2.5.7. Estimate of fall-run chinook pre-harvest recruits and spawners in the Cowlitz River.

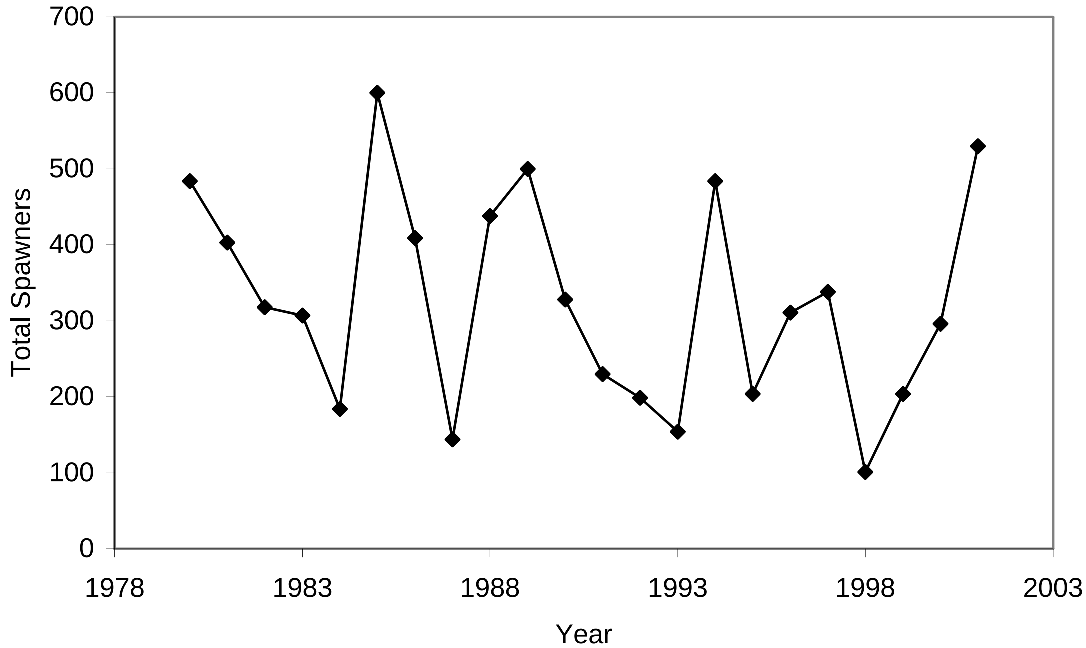


Figure A.2.5.8. East Fork Lewis River fall-run chinook total spawner abundance (almost all spawners are of natural origin).

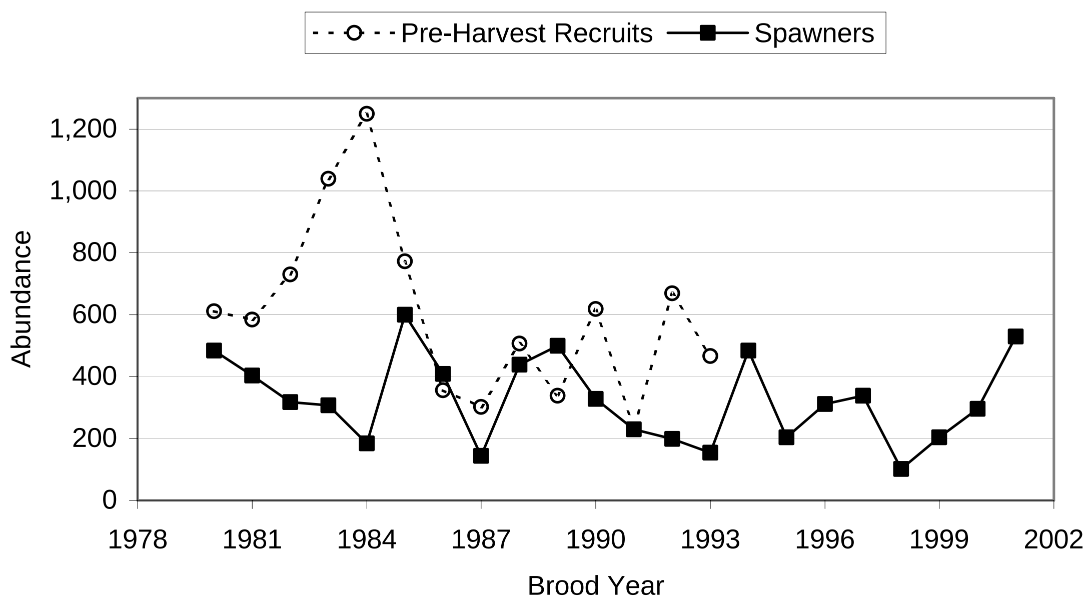


Figure A.2.5.9. Estimate of fall-run chinook preharvest recruits and spawners in the East Fork Lewis River.

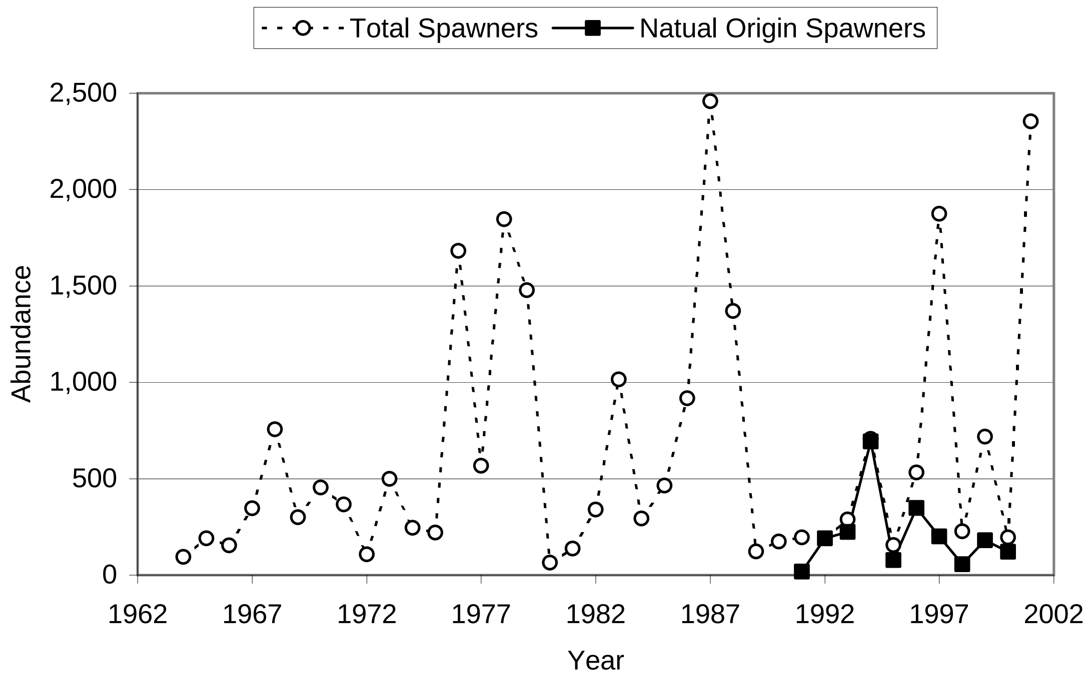


Figure A.2.5.10. Elochoman River fall-run chinook spawner abundance.

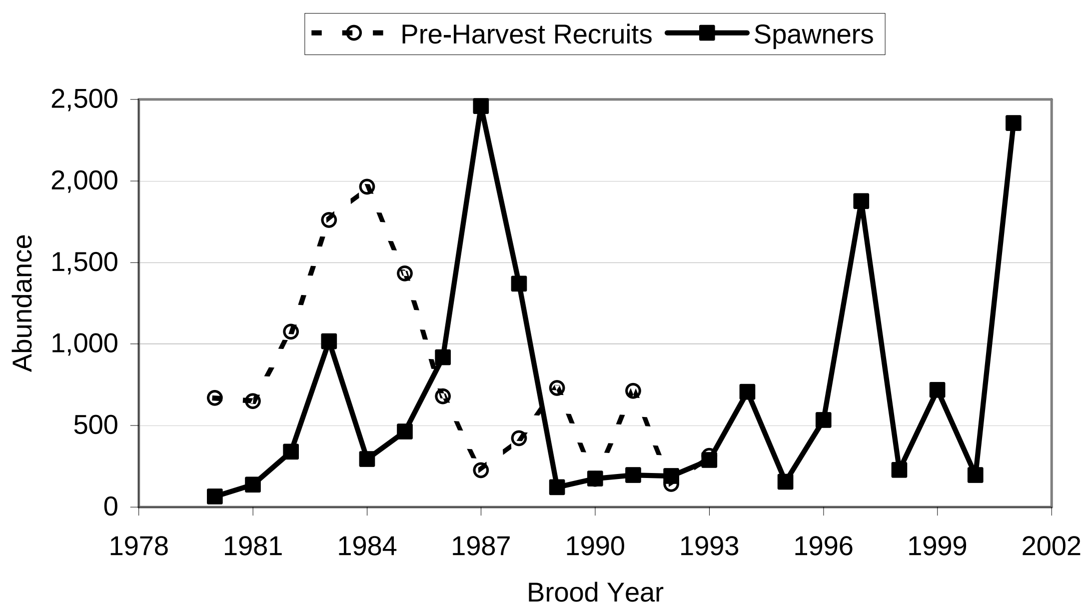


Figure A.2.5.11. Estimate of fall-run chinook pre-harvest recruits and spawners in the Elochoman River.

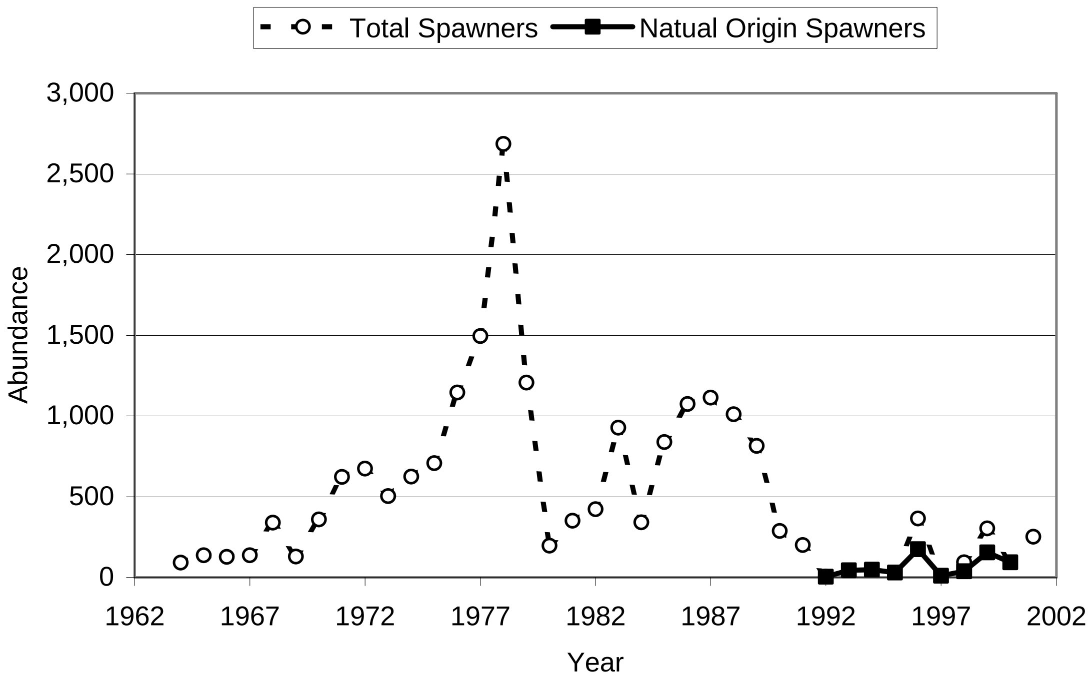


Figure A.2.5.12. Grays River fall-run chinook spawner abundance.

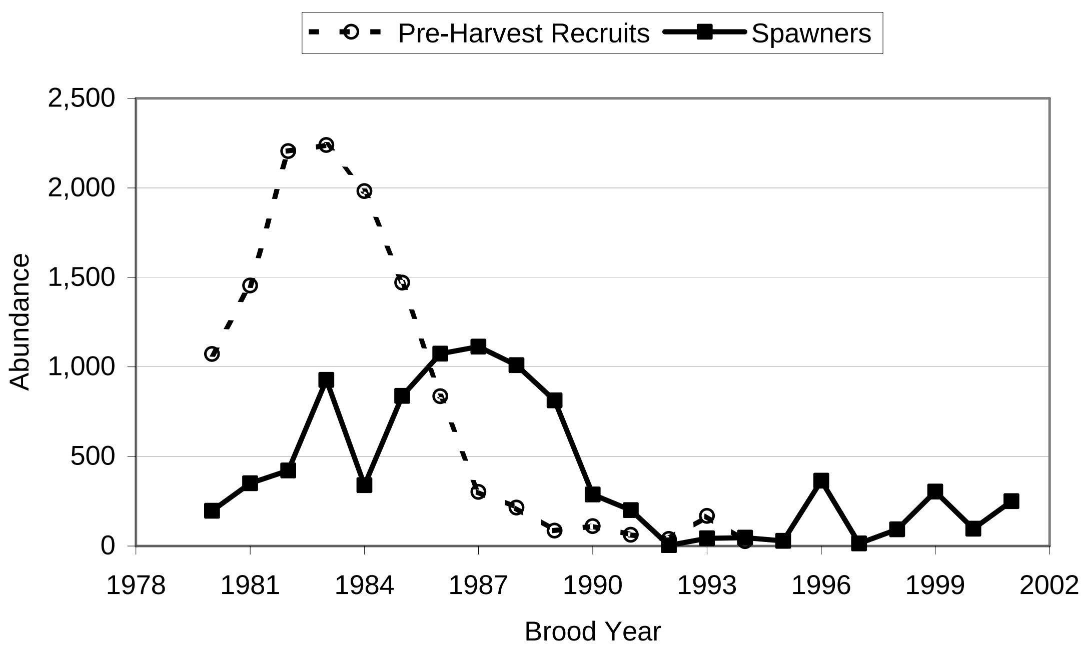


Figure A.2.5.13. Estimate of Grays River fall-run chinook pre-harvest recruits and spawners.

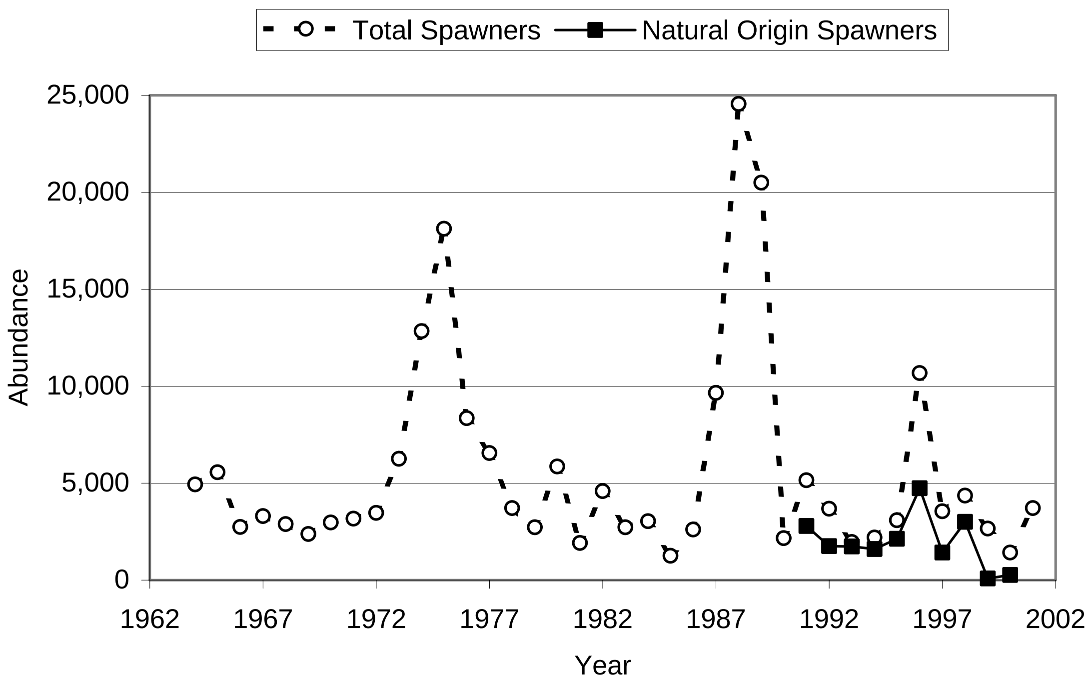


Figure A.2.5.14. Kalama River fall-run chinook spawner abundance.

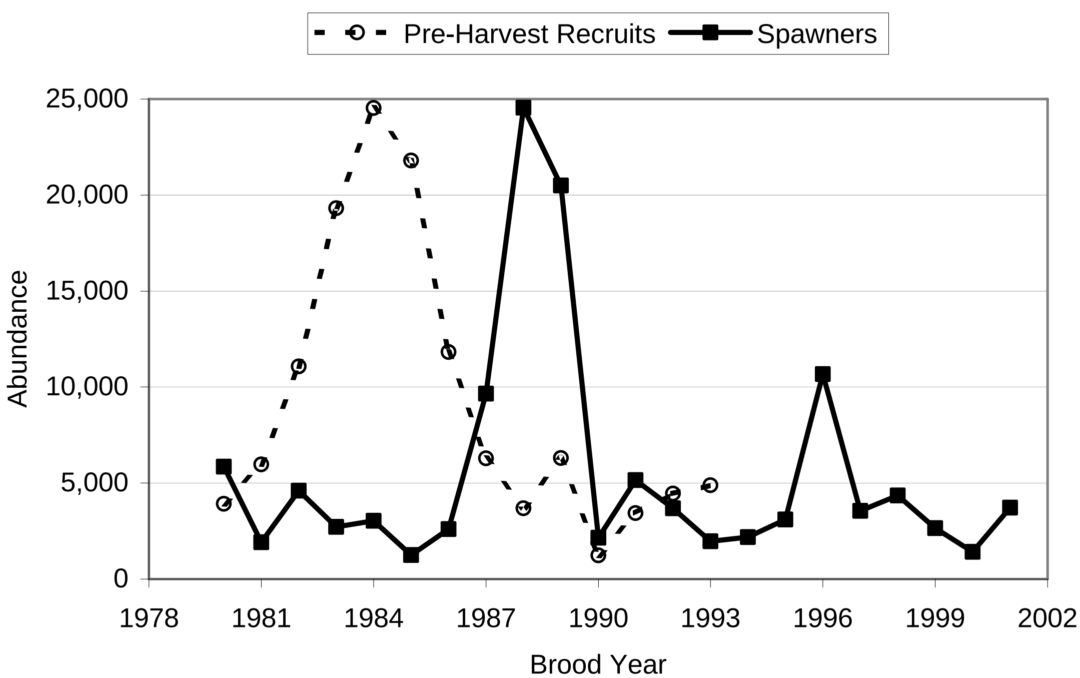


Figure A.2.5.15. Estimate of Kalama River fall-run chinook pre-harvest recruits and spawners.

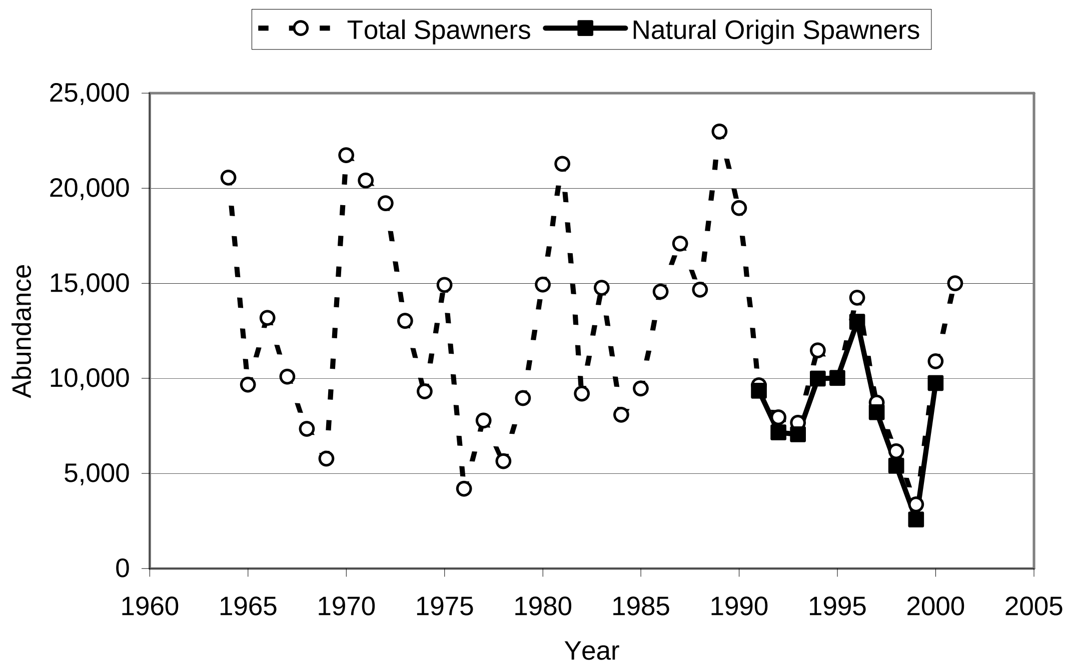


Figure A.2.5.16. Lewis River late fall-run (bright) chinook spawner abundance.

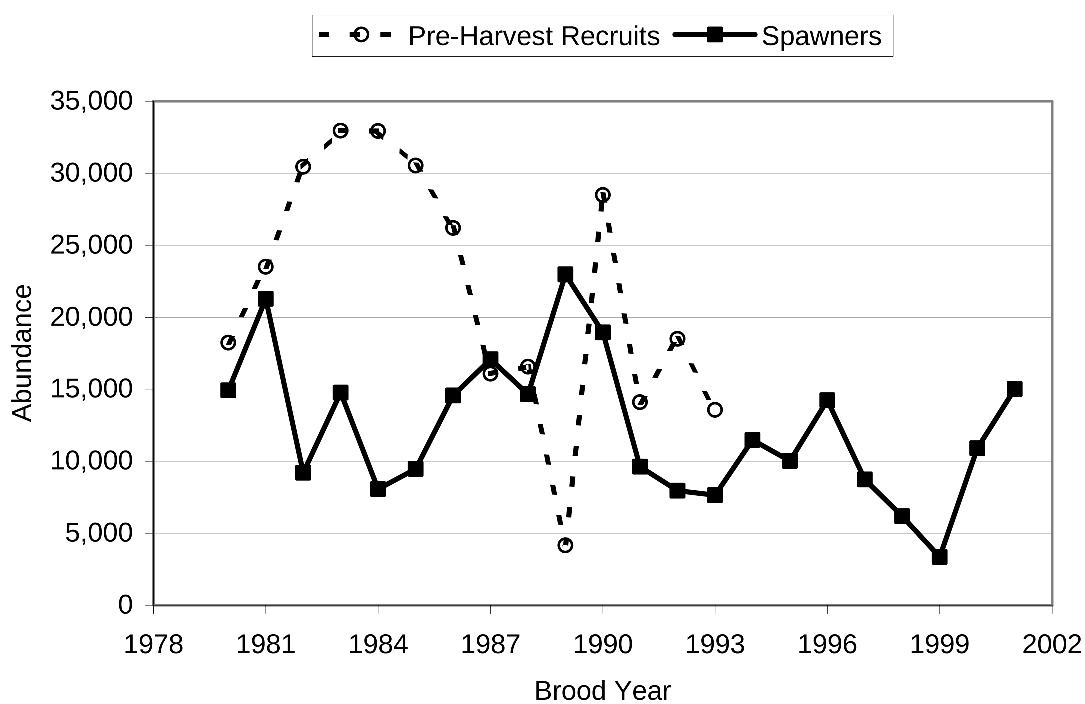


Figure A.2.5.17. Estimate of Lewis River late fall-run (bright) chinook pre-harvest recruits and spawners.

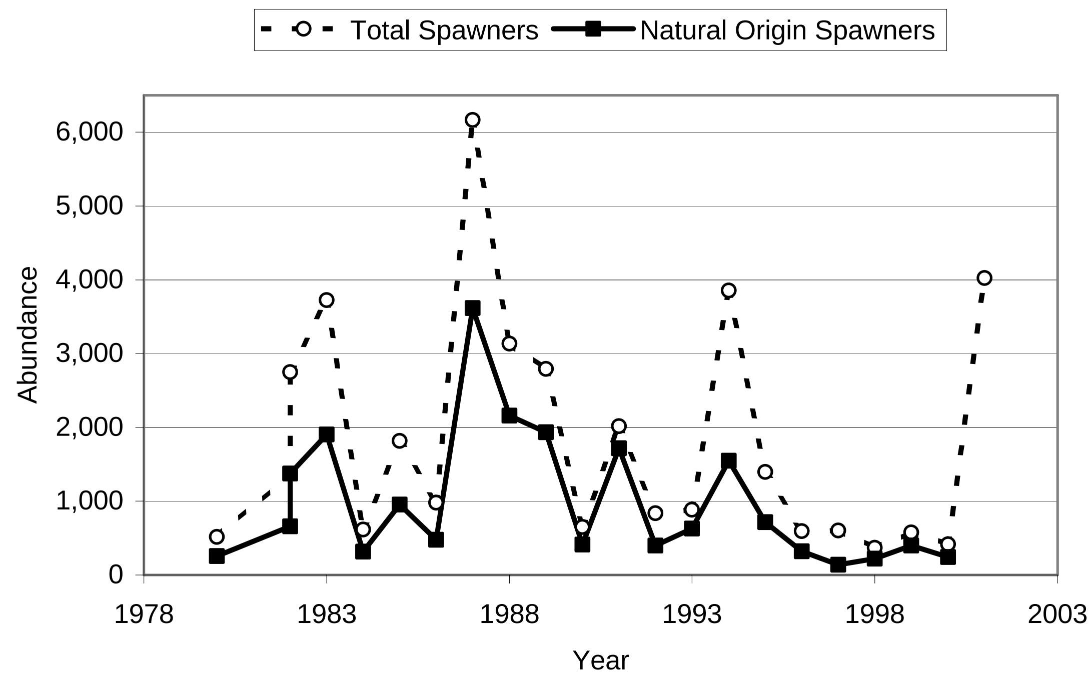


Figure A.2.5.18. Mill/Germany/Abernathy Creeks fall-run chinook spawner abundance.

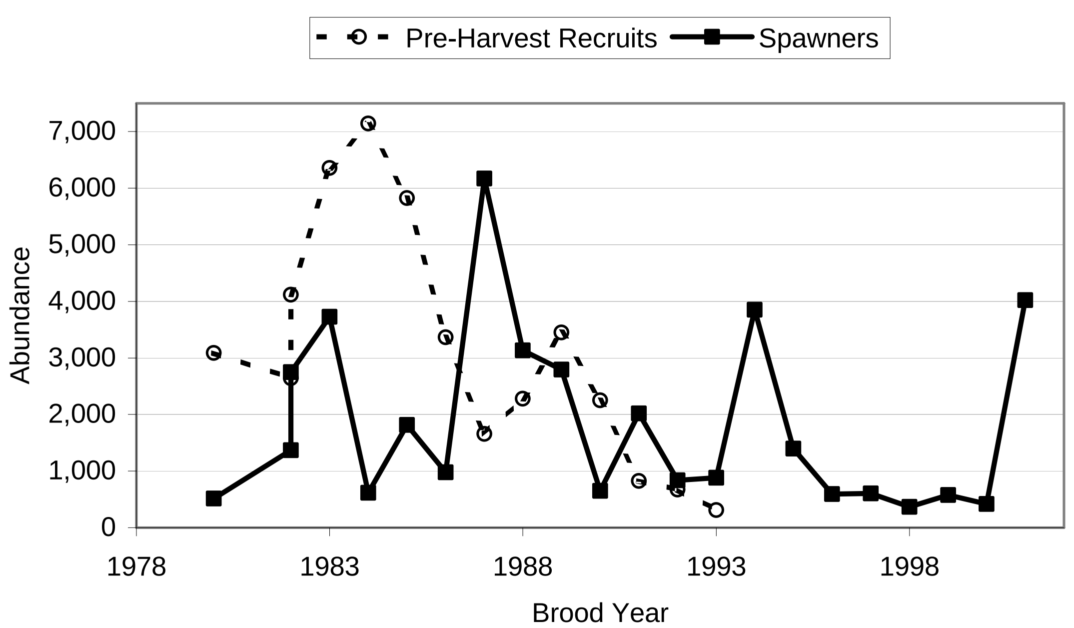


Figure A.2.5.19. Estimate of Mill/Germany/Abernathy Creeks fall-run chinook pre-harvest recruits and spawners.

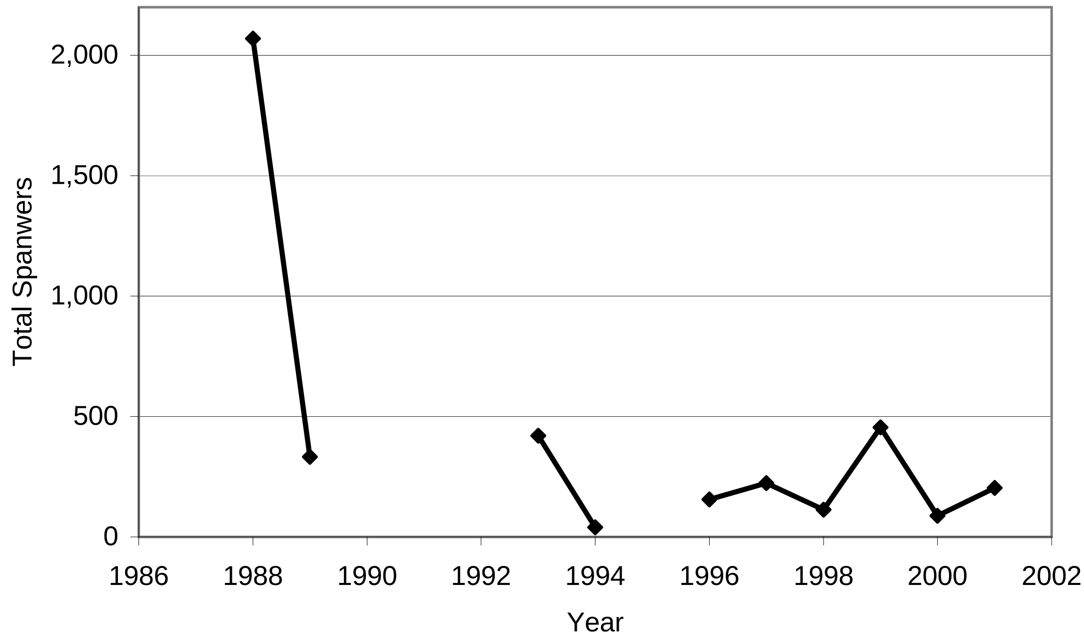


Figure A.2.5.20. Sandy River fall-run chinook spawner abundance.

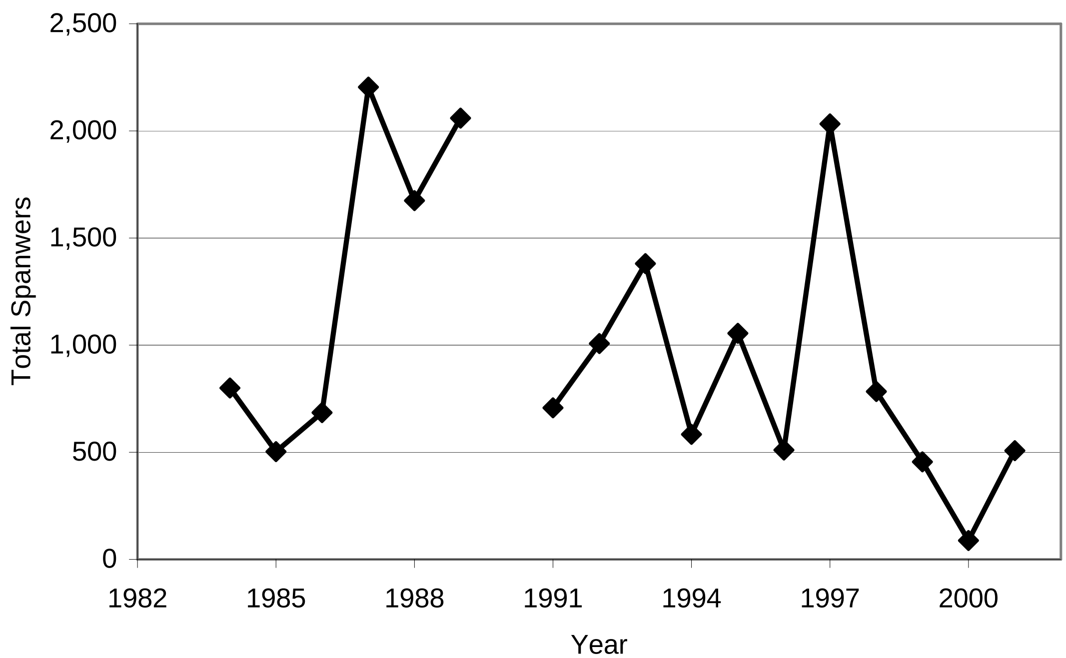


Figure A.2.5.21. Sandy River late fall-run (bright) chinook spawner abundance.

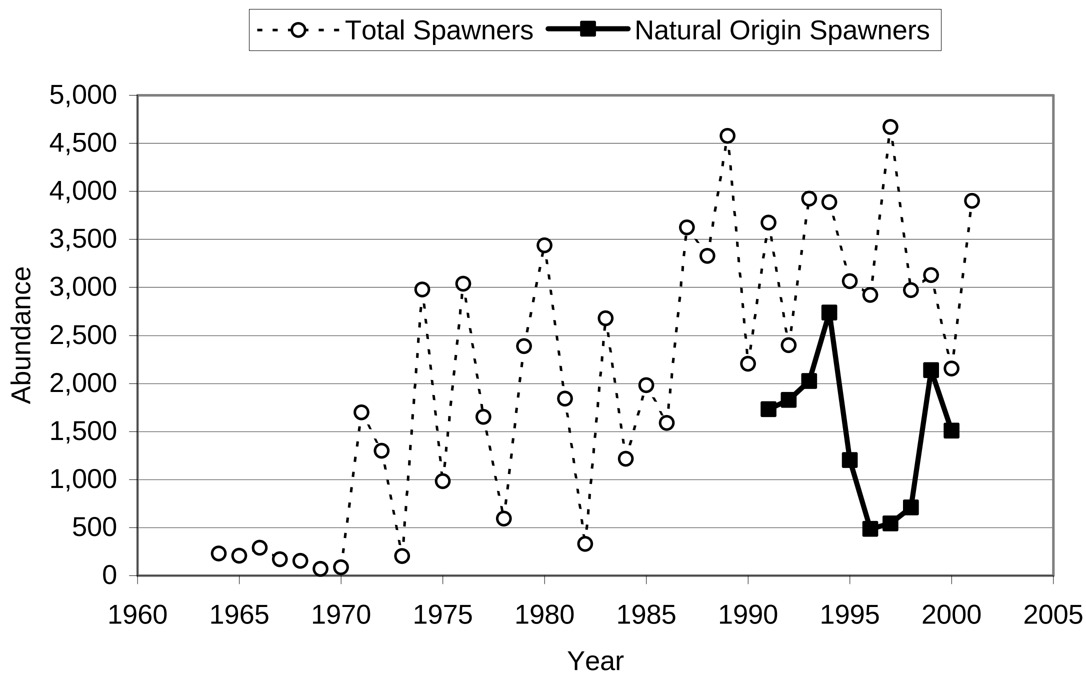


Figure A.2.5.22. Washougal River fall-run chinook spawner abundance.

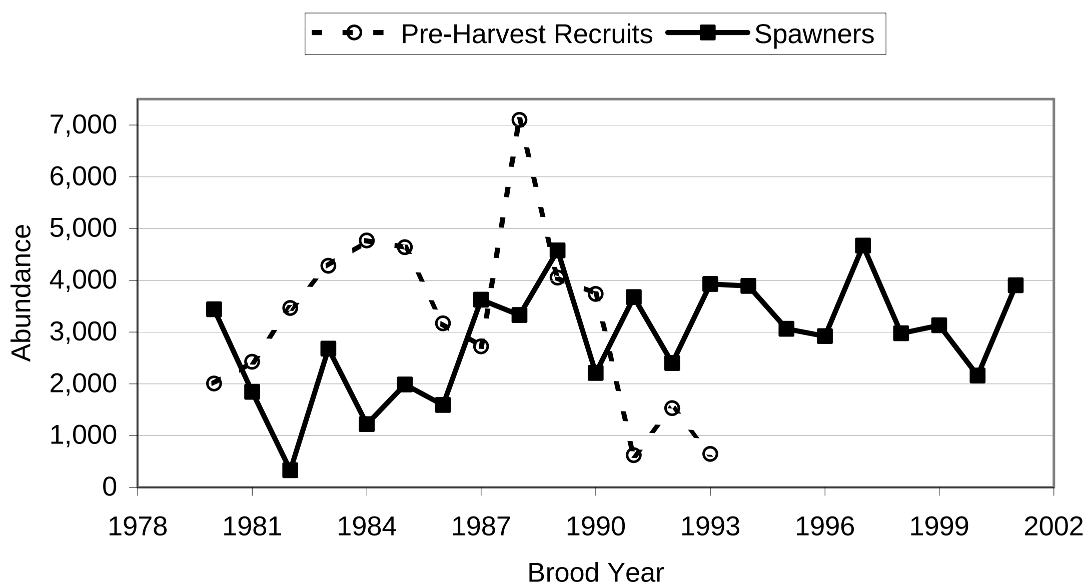


Figure A.2.5.23. Estimate of Washougal River fall-run chinook pre-harvest recruits and spawners.

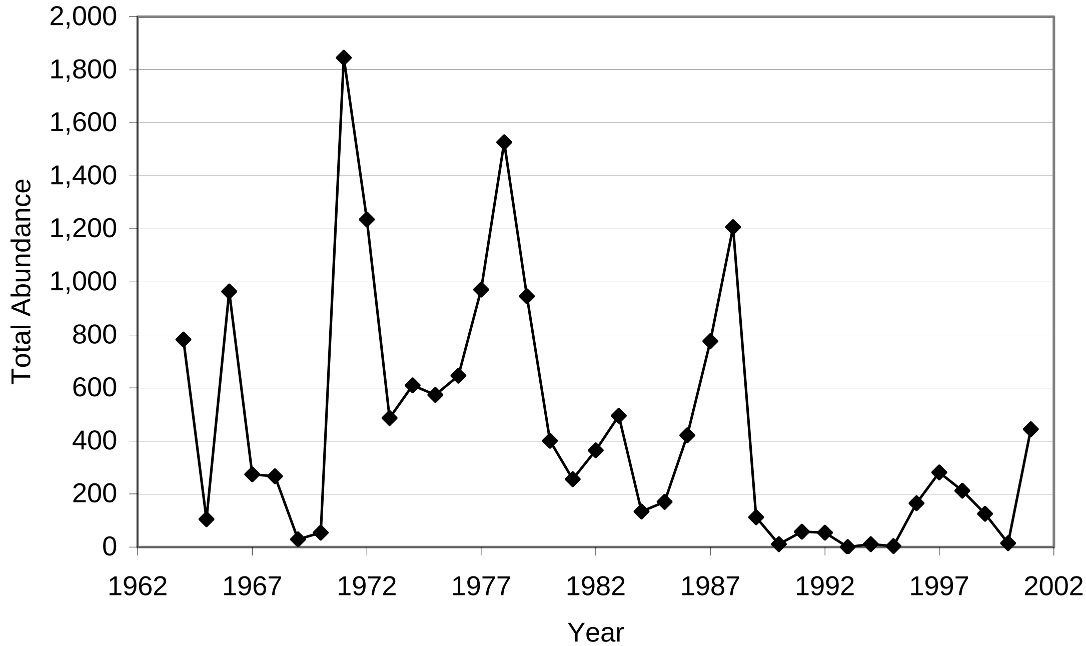


Figure A.2.5.24. Wind River fall-run chinook total spawner abundance (hatchery and natural origin).

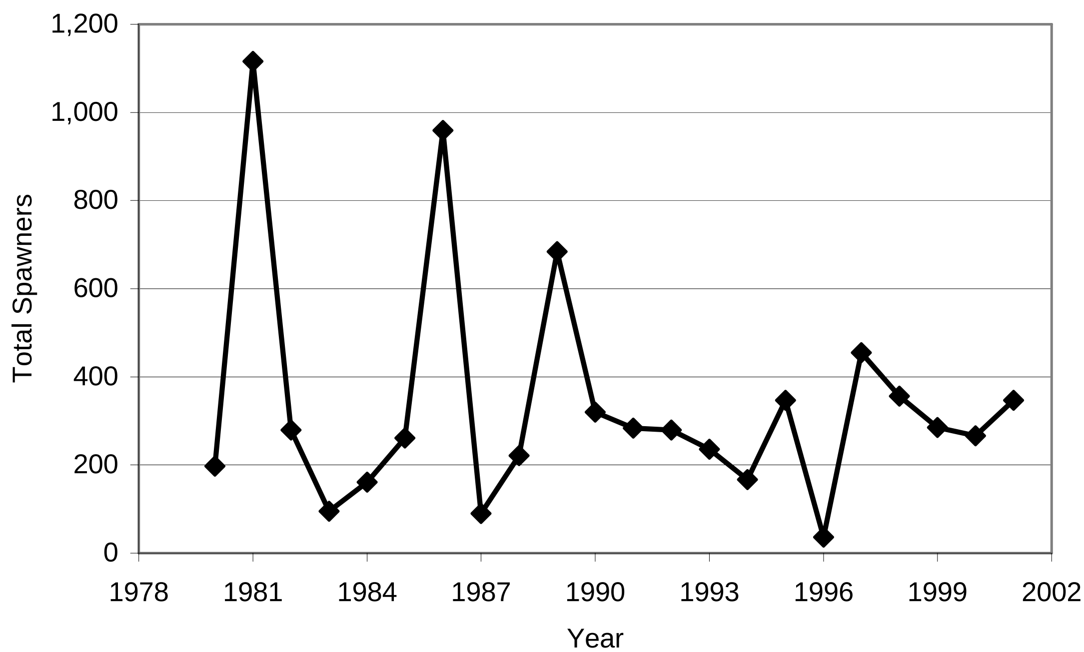


Figure A.2.5.25. Cowlitz River spring-run chinook total spawner abundance below Mayfield Dam (the majority of spawners are of hatchery origin).

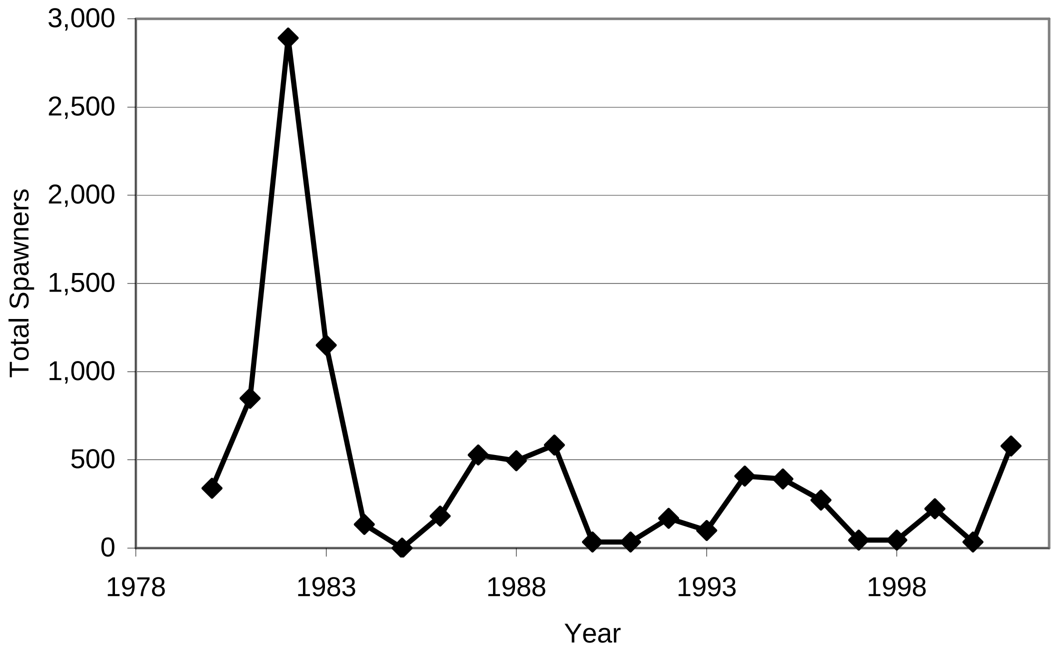


Figure A.2.5.26. Kalama River spring-run chinook total spawner (the majority of spawners are of hatchery origin).

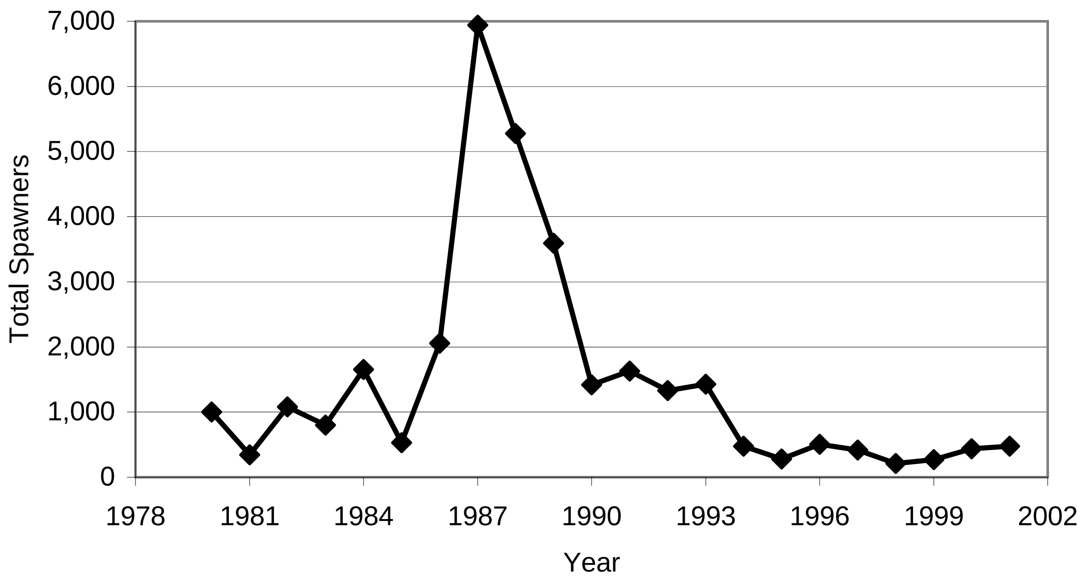


Figure A.2.5.27. Lewis River spring-run chinook total spawner abundance below Merwin Dam (the majority of spawners are of hatchery origin).

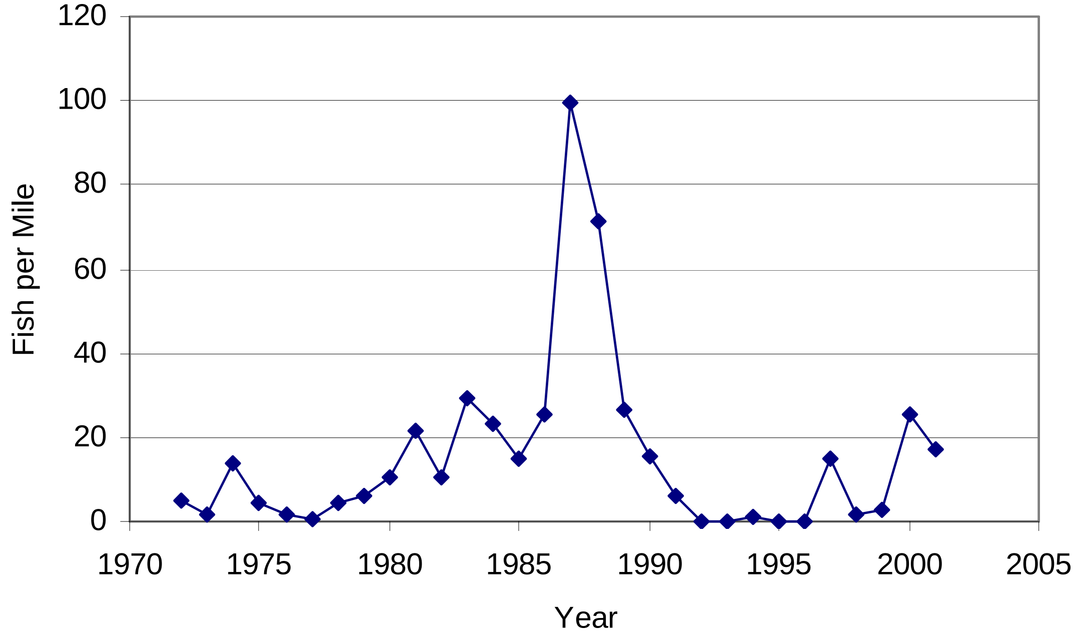


Figure A.2.5.28. Youngs Bay chinook fish-per-mile.

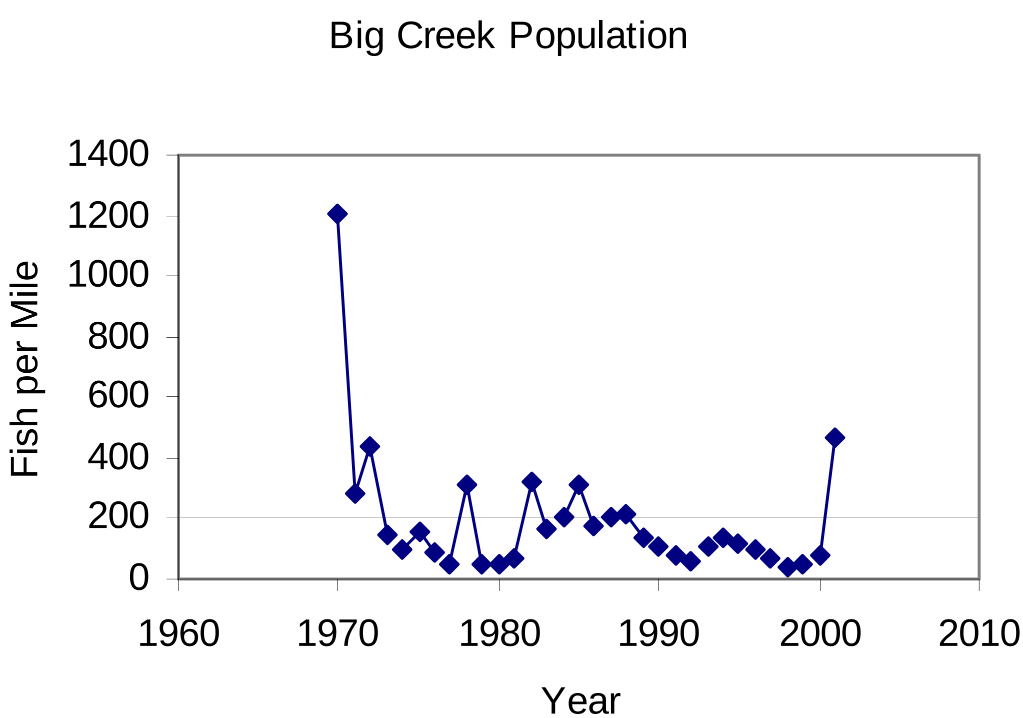


Figure A.2.5.29. Big Creek chinook fish-per-mile.

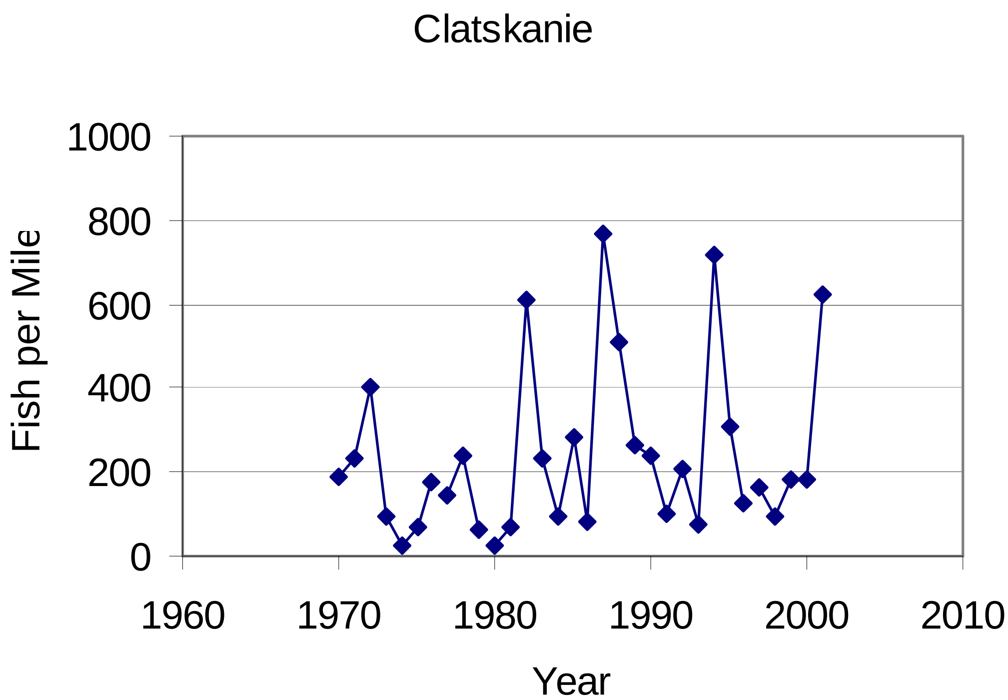


Figure A.2.5.30. Clatskanie River chinook fish-per-mile.

A.2.6 UPPER WILLAMETTE RIVER CHINOOK SALMON

A.2.6.1 Summary of Previous BRT Conclusions

The status of Upper Willamette River chinook was initially reviewed by NMFS in 1998 (Myers et al.1998) and updated in that same year (NMFS 1998). In the 1998 update, the BRT noted several concerns for this ESU. The previous BRT was concerned about the few remaining populations of spring chinook salmon in the Upper Willamette River ESU, and the high proportion of hatchery fish in the remaining runs. The BRT noted with concern that ODFW was able to identify only one remaining naturally-reproducing population in this ESU–the spring chinook salmon in the McKenzie River. The previous BRT was concerned about severe declines in short-term abundance that occurred throughout the ESU, and the McKenzie River population had declined precipitously, indicating that it may not be self-sustaining. The 1998 BRT also noted the potential for interactions between native spring-run and introduced fall-run chinook salmon had increased relative to historical times due to fall-run chinook salmon hatchery programs and the laddering of Willamette Falls. The previous BRT partially attributed the declines in spring chinook salmon in the Upper Willamette River ESU to the extensive habitat blockages caused by dam construction. The previous BRT was encouraged by efforts to reduce harvest pressure on naturally-produced spring chinook salmon in Upper Willamette River tributaries, and the increased focus on selective marking of hatchery fish should help managers targeting specific populations of wild or hatchery chinook salmon. A majority of the previous (1998) BRT concluded that the Lower Columbia River ESU was likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.

Current Listing Status: threatened

A.2.6.2 New Data and Updated Analyses

New data for this update include spawner abundance through 2002 in Clackamas, 2001 in McKenzie and 2001 at Willamette Falls. In addition, new data include updated redd surveys in the basin, new estimates of the fraction of hatchery-origin spawners in McKenzie and North Santiam from an otolith marking study, the first estimate of hatchery fraction in the Clackamas (2002 data), and information on recent hatchery releases. New analyses for this update include: the designation of relatively demographically independent populations, recalculation of previous BRT metrics in the McKenzie with additional years of data, estimates of current and historically available kilometers of stream, and updates on current hatchery releases.

Historical population structure—As part of its effort to develop viability criteria for UW chinook, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. (2002) hypothesized that the ESU historically consisted of 7 spring run populations (Figure A.2.6.1). The populations identified in Myers et al. (2002) are used as the units for the new analyses in this report.

Abundance and trends

References for abundance time series and related data are in Appendix A.5.3. Recent abundance of natural-origin spawners, recent fraction of hatchery-origin spawners, and recent harvest rates for UW Chinook populations are summarized in Table A.2.6.1. The total number of spring chinook spawners passing Willamette Falls from 1953 to 2001 is shown in Figure A.2.6.2. All spring chinook in the ESU, except those entering the Clackamas River, must pass Willamette Falls. There is no assessment of the ratio of hatchery-origin to natural-origin chinook passing the falls, but the majority of fish are undoubtedly of hatchery origin. (Natural-origin fish are defined has having had parents that spawned in the wild as opposed to hatchery -origin fish whose parents spawned in a hatchery.) The status of individual populations is discussed below.

Clackamas—The count of spring chinook passing the North Fork dam on the Clackamas from 1958 to 2002 are shown in Figure A.2.6.3 (Cramer 2002). The total number of chinook passing above the dam has exceeded 1,000 in most years since 1980 and the last several year show large increases. However, the majority of these fish are likely of hatchery origin. The only year for which hatchery-origin estimates are available is 2002 and the estimate is 64% of hatchery origin. Although the majority of spring chinook spawning habitat is above North Fork Dam, spawning is observed below the dam. The majority of spawning below the dam is also considered to be by hatchery-origin spawners. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Molalla—A 2002 survey of 16.3 miles of stream in the Molalla found 52 redds. However, 93% of the carcasses recovered in the Molalla in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners (Schroeder et al. 2002), so the true fraction is likely in excess of 93 % (i.e. near 100%). The Molalla natural spring chinook population is believed to be extirpated, or nearly so.

North Santiam—Survey estimates of redds per mile in the North Santiam are shown in Figure A.2.6.4 (from Schroeder et al 2002). The number of stream miles surveyed varies between 26.8 and 43.5. The total redds counted in a year varies between 116 and 310. Schroeder et al. (2002) estimate an escapement of 94 natural-origin spawners above Bennett Dam in 2000 and 151 in 2001. These natural-origin spawners were greatly outnumbered by hatchery-origin spawners (2,192 and 6,635 in 2000 and 2001 respectively). This resulted in estimated 94% hatchery-origin spawners in 2000 and 98% in 2001. This population is not considered self-sustaining.

South Santiam—A 2002 survey of 50.8 miles of stream in the South Santiam River below Foster dam found 982 redds. However, 84% of the carcasses recovered in the South Santiam in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners (Schroeder et al 2002), so the true fraction is likely in excess of 84 %. This population is not considered self-sustaining.

Calapooia—A 2002 survey of 11.1 miles of stream in the Calapooia above Brownsville found 16 redds (Schroeder et al 2002). The carcasses recovered in the Calapooia in 2002 were too decomposed to determine the presence or absence of fin clips. However, it was assumed that all the fish were surplus hatchery fish outplanted from the South Santiam hatchery (Schroeder et al. 2002). The Calapooia natural spring chinook population is believed to be extirpated, or nearly so.

McKenzie—The time series of total spring chinook counts and natural-origin fish passing Leaburg Dam on the McKenzie is shown in Figure A.2.6.5. The average fraction of hatchery-origin fish passed above the dam from 1998 to 2001 was estimated at 26%. Redds are observed below Leaburg Dam, but the fraction of hatchery-origin fish is higher (Schroeder et al 2002). The fraction of fin-clipped spring chinook carcasses recovered below Leaburg was 72% in 2000 and 67% in 2001. Again, fin clip recoveries tend to underestimate the fraction of hatchery-origin spawners. The spring chinook population above Leaburg Dam in the McKenzie is considered the best in the ESU, but with over 20% of the fish of hatchery origin, it is difficult to determine if this population would be naturally self-sustaining. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Middle Fork Willamette—A 2002 survey of 17 miles of the mainstem Middle Fork found 64 redds. However, 77% of the carcasses recovered in the Middle Fork in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). In Fall Creek, a tributary of the Middle Fork, 171 redds in 13.3 miles were found in 2002. The 2002 carcass survey found 39% of fish fin-clipped. Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners. This population is not considered self-sustaining.

No formal trend analyses were conducted on any of the UW chinook populations. The two populations with long time series of abundance (Clackamas and McKenzie) have insufficient information on the fraction of hatchery-origin spawners to permit a meaningful analysis.

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the UW (Table A.2.6.1). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will overestimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is significantly reduced from the historical condition.

Table A.2.6.1. Historical populations of Upper Willamette spring-run chinook salmon. For the McKenzie River population, hatchery fraction is the average percent of spawners of hatchery origin over the last four years. For the Clackamas River population, only one year of hatchery fraction estimate is available (2002). Hatchery fraction in the Molalla, South Santiam and Middle Fork are minimum estimates based on the ratio of adipose marked verses unmarked fish recovered in 2001 (Schroeder et al. 2002). The current and historical habitat estimates are based on analysis by Steel and Sheer (2002).

Population	Hatchery Fraction (%)	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio (%)
Clackamas River	64	369	475	78
Molalla River	>93	432	688	63
North Santiam River	97	173	269	64
South Santiam River	>84	445	658	68
Calapooia River	Estimated @ 100%	163	253	65
McKenzie River	26	283	382	74
Middle Fork Willamette River	>77	197	425	46
Total		2,063	3,150	65

Hatchery releases

A large number of spring chinook are released in the Upper Willamette as mitigation for the loss of habitat above federal hydroprojects (Table A.2.6.2). This hatchery production is considered a potential risk, because it masks the productivity of the natural population, interbreeding of hatchery and natural fish poses potential genetic risks and the incidental take from the fishery promoted by the hatchery production can increase adult mortality. Harvest retention is only allowed for hatchery marked fish, but take from hooking mortality and non-compliance is still a potential issue.

Fall chinook are not native to the upper Willamette and are not part of the Upper Willamette chinook ESU. Fall chinook hatchery fish are no longer released into the upper Willamette, though there have been substantial releases in the past (Figure A.2.6.6).

A.2.6.3 ESU Summary

The updated information provided in this report, the information contained in previous UW chinook status reviews, and preliminary analysis by the WLC-TRT, indicate that most natural spring chinook populations are likely extirpated or nearly so. The only population considered potentially self-sustaining is the McKenzie. However, its abundance has been relatively low (low thousands) with a substantial number of these fish being of hatchery origin. The population has shown a substantial increase in the last couple of years, hypothesized to be a result of increase ocean survival. It is unknown what ocean survivals will be in the future and the long-term sustainability of this population in uncertain.

Table A.2.6.2. Upper Willamette spring-run chinook hatchery releases (compiled by Waknitz 2002).

Watershed	Years	Hatchery	Stock	Release Site	Total
Willamette R	1994	Dexter Pd	McKenzie	L Willamette R	73,028
	1995	Dexter Pd	Willamette	L Willamette R	137,573
	1995	Lone Star	Clackamas	L Willamette R	59,654
	1995	Marion Forks	N Santiam	L Willamette R	40,320
	1993, 1994	McKenzie	McKenzie	L Willamette R	344,089
	1992, 1993	Step	Clackamas	L Willamette R	70,193
	1993, 1994	Step	McKenzie	L Willamette R	331,446
	1993-1995	McKenzie	Clackamas	L Willamette R	125,585
	1996-1999	Willamette	McKenzie	L Willamette R	225,122
	1995-1996	Willamette	N Santiam	L Willamette R	81,513
	1995-1999	McKenzie	McKenzie	L Willamette R	574,117
Clackamas R	1991-1994	Clackamas	Clackamas	Clackamas R	4,358,092
	1995-2002	Clackamas	Clackamas	Clackamas R	9,182,916
	1996-2001	McKenzie	McKenzie	Clackamas R	1,332,542
	1991	Eagle Creek NFH	Clackamas	Eagle Cr	556,814

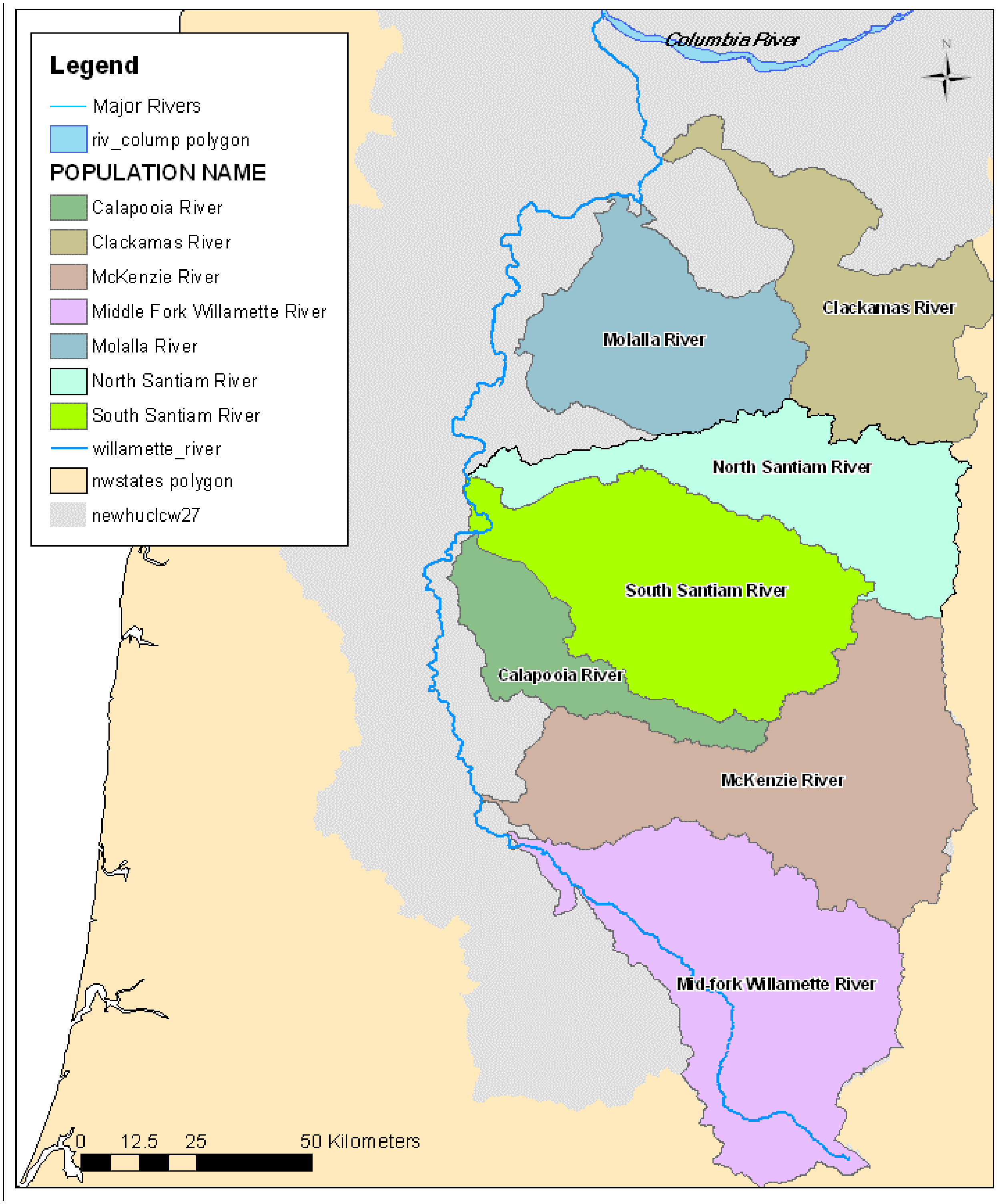


Figure A.2.6.1. Historical populations of spring-run chinook in the Willamette ESU (Myers et al. 2002).

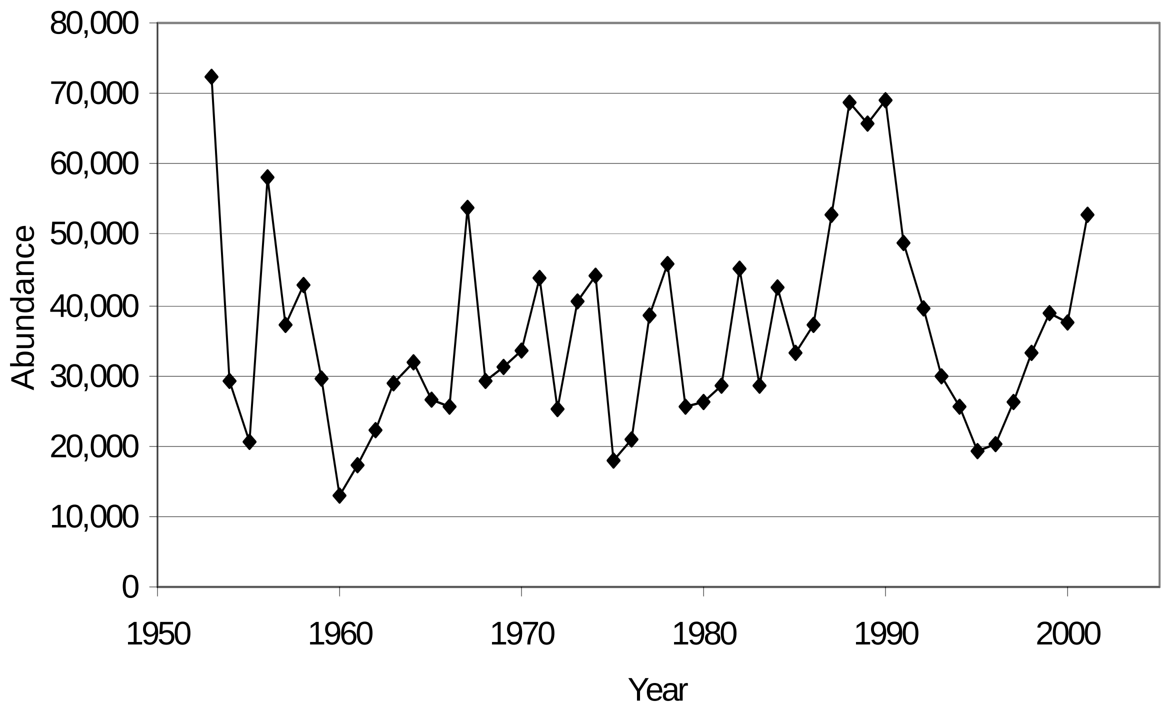


Figure A.2.6.2. Counts of spring-run chinook passing Willamette Falls. The count is of mixed natural and hatchery origin, with the majority of fish likely of hatchery origin.

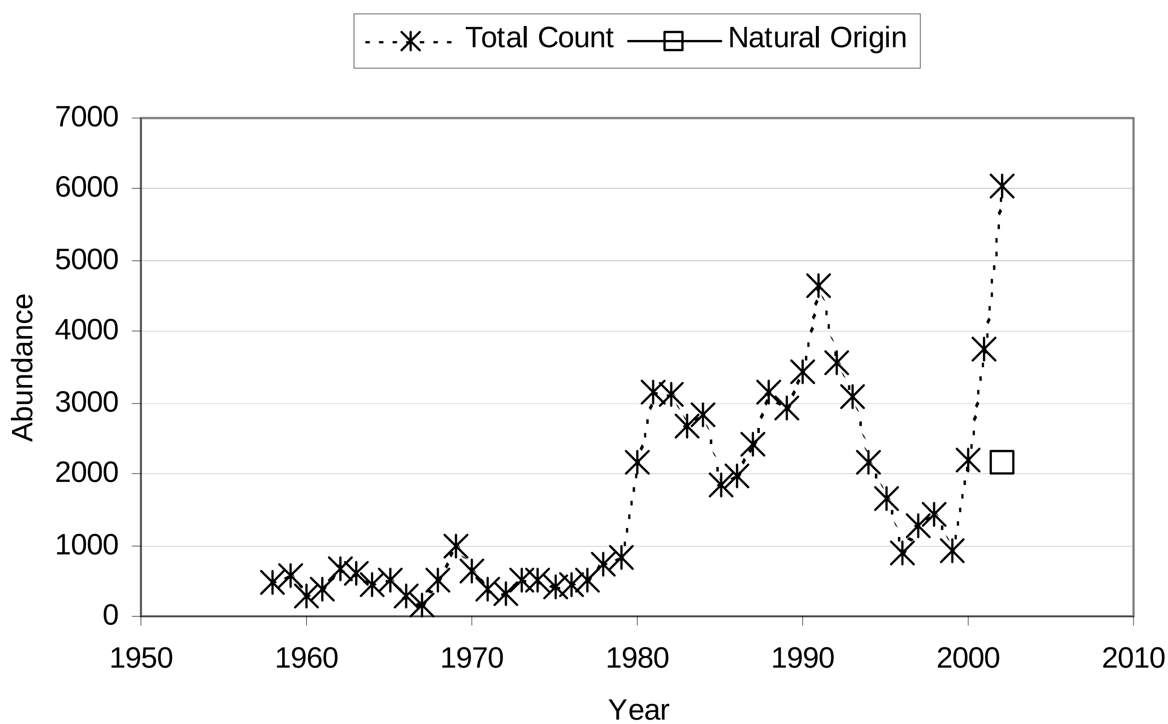


Figure A.2.6.3. Counts of spring-run chinook passing North Fork Dam on the Clackamas River (Cramer 2002). The total count is all fish passing above the dam. There is only one estimate (in 2002) of the number of fish passing above the dam that are of natural origin.

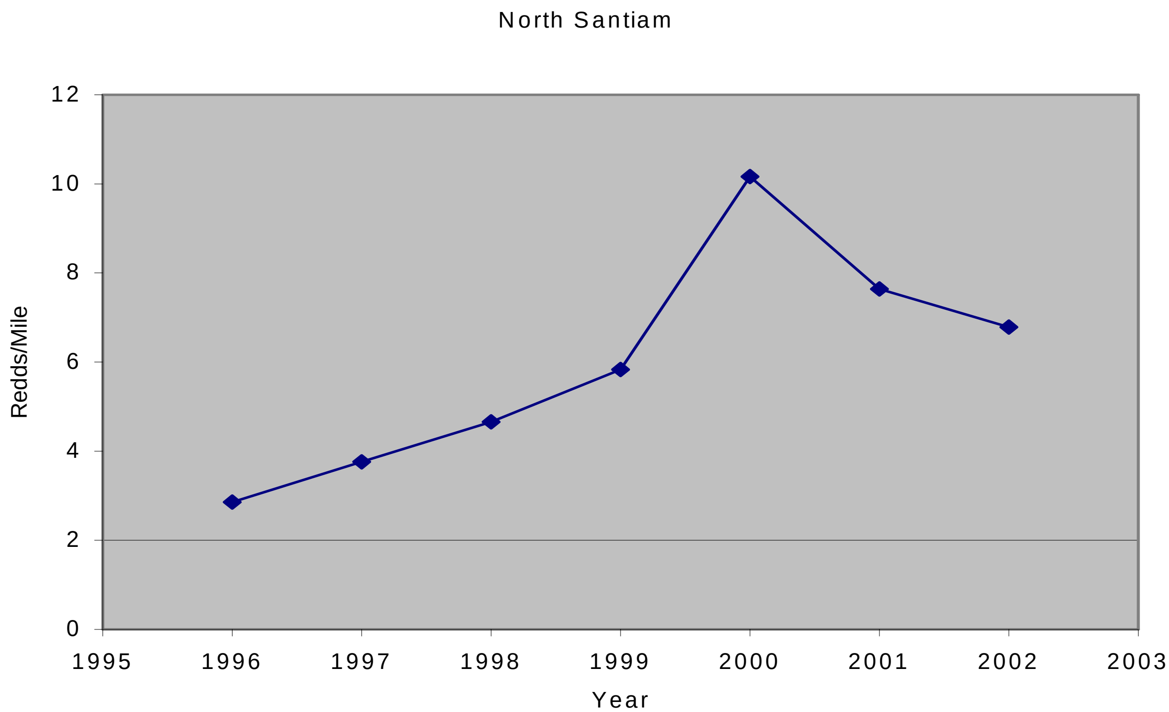


Figure A.2.6.4. North Santiam redds per mile (data from Schroeder et al. 2002). The number of stream miles surveyed varies between 26.8 and 43.5 miles. The total redds counted in a year varies between 116 and 310. Over 95% of the spawners are estimated of hatchery origin

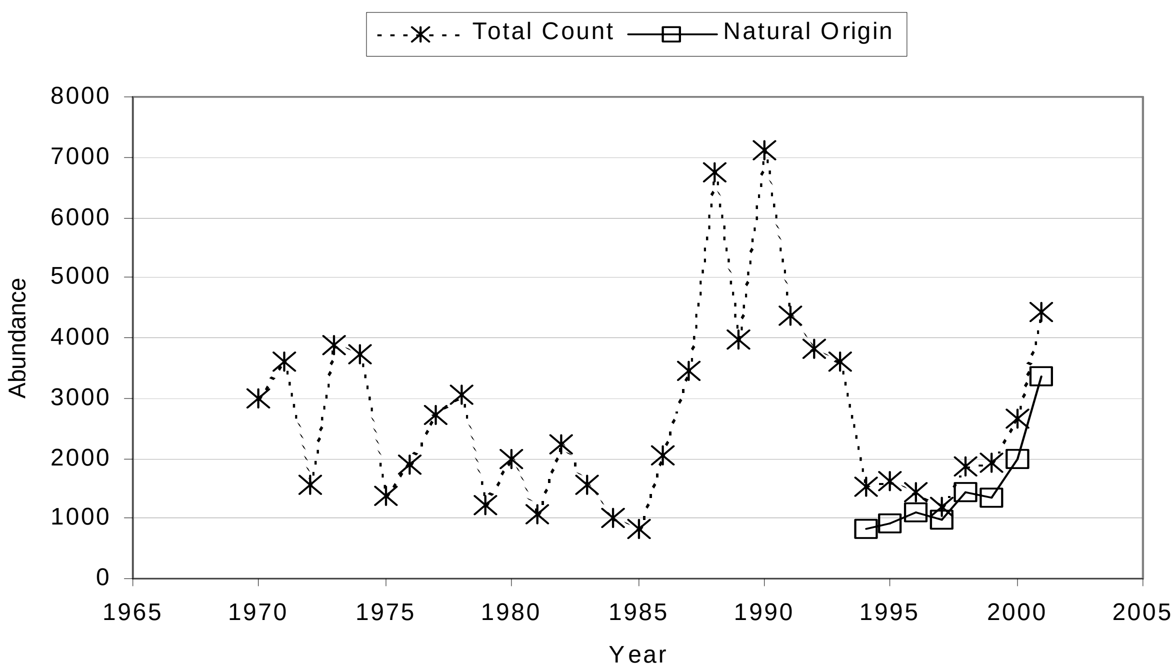


Figure A.2.6.5. Counts of McKenzie River spring-run chinook at Leaburg Dam.

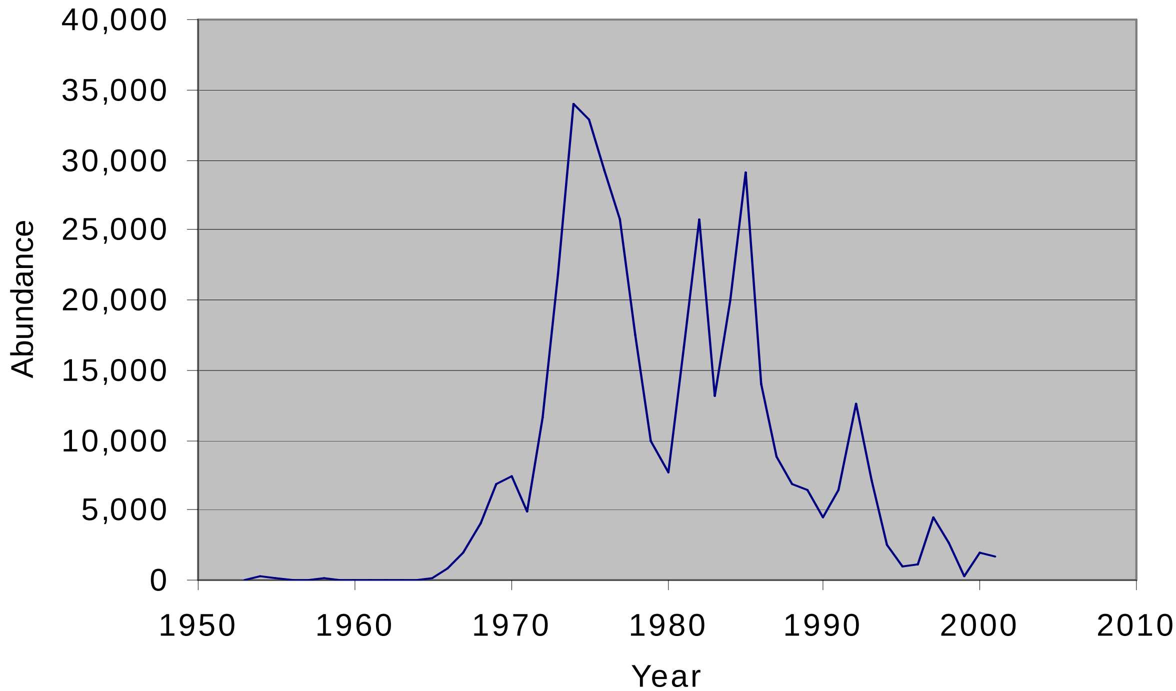


Figure A.2.6.6. Counts of fall-run chinook at Willamette Falls. Fall-run chinook are not native in the Upper Willamette River and are not in the in the Upper Willamette chinook salmon ESU.

A.2.7 CALIFORNIA COASTAL CHINOOK SALMON

Primary contributor: Eric P. Bjorkstedt (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.7.1 Summary of Previous BRT Conclusions

The status of chinook salmon throughout California and the Pacific Northwest was formally assessed in 1998 (Myers et al. 1998). Substantial scientific disagreement about the biological data and its interpretation persisted for some Evolutionarily Significant Units (ESUs); these ESUs were reconsidered in a subsequent status review update (NMFS 1999). Information from those reviews regarding ESU structure, analysis of extinction risk, risk factors, and hatchery influences is summarized in the following sections.

ESU structure

The initial status review proposed a single ESU of chinook salmon inhabiting coastal basins south of Cape Blanco and the tributaries to the Klamath River downstream of its confluence with the Trinity River (Myers et al. 1998). Subsequent review of an augmented genetic data set and further consideration of ecological and environmental information led to the division of the originally proposed ESU into the Southern Oregon and Northern California Coastal Chinook Salmon ESU and the California Coastal Chinook Salmon ESU (NMFS 1999). The California Coastal Chinook Salmon ESU currently includes chinook salmon from Redwood Creek to the Russian River (inclusive).

Summary of risk factors and status

The California Coastal Chinook Salmon ESU is listed as Threatened. Primary causes for concern were low abundance, reduced distribution (particularly in the southern portion of the ESU's range), and generally negative trends in abundance; all of these concerns were especially strong for spring-run chinook salmon in this ESU (Myers et al. 1998). Data for this ESU are sparse and, in general of limited quality, which contributes to substantial uncertainty in estimates of abundance and distribution. Degradation of the genetic integrity of the ESU was considered to be of minor concern and to present less risk for this ESU than for other ESUs.

Previous reviews of conservation status for chinook salmon in this area exist. Nehlsen et al. (1991) identified three putative populations (Humboldt Bay Tributaries, Mattole River, and Russian River) as being at high risk of extinction and three other populations (Redwood Creek, Mad River, and Lower Eel River) as being at moderate risk of extinction. Higgins et al. (1992) identified seven "stocks of concern," of which two populations (tributaries to Humboldt Bay and the Mattole River) were considered to be at high risk of extinction. Some reviewers indicate that chinook salmon native to the Russian River have been extirpated.

Historical estimates of escapement are presented in Table A.2.7.1. These estimates are based on professional opinion and evaluation of habitat conditions, and thus do not represent rigorous estimates based on field sampling. Historical time series of counts of upstream migrating adults are available for Benbow Dam (South Fork Eel River 1938-1975), Sweasy Dam (Mad River 1938-1964), and Cape Horn Dam (Van Arsdale Fish Station, Eel River); the latter represent a small, unknown and presumably variable fraction of the total run to the Eel River. Data from cursory, nonsystematic stream surveys of two tributaries to the Eel River (Tomki and Sprowl Creeks) and one tributary to the Mad River (Canon Creek) were also available; these data provide crude indices of abundance.

Previous status reviews considered the following to pose significant risks to the California Coastal Chinook Salmon ESU: degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, mining, and severe recent flood events (exacerbated by land use practices). Special concern was noted regarding the more precipitous declines in distribution and abundance in spring-run chinook salmon. Many of these factors are particularly acute in the southern portion of the ESU range and were compounded by uncertainty stemming from the general lack of population monitoring in California (Myers et al. 1998).

In previous status reviews, the effects of hatcheries and transplants on the genetic integrity of the ESU elicited less concern than other risk factors for this ESU, and were less of a concern for this ESU in comparison to other ESUs.

Listing status

The California Coastal Chinook Salmon ESU is currently listed as “Threatened.”

Table A.2.7.1. Historical estimates of abundance of chinook salmon in the California Coastal Chinook Salmon ESU.

Selected Watersheds	**CDFG 1965**	**Wahle & Pearson 1987**
Redwood Creek	5,000	1,000
Mad River	5,000	1,000
Eel River	55,000	17,000
Mainstem Eel[a]	13,000	
Van Duzen Rivera[a]	2,500	
Middle Fork Eel[a]	13,000	
South Fork Eel[a]	27,000	
Bear River		100
Small Humboldt County Rivers	1,500	
Miscellaneous Rivers North of Mattole		600
Mattole River	5,000	1,000
Noyo River	50	
Russian River	500	50
Total	72,550	20,750

[a]Entries for subbasins of the Eel River Basin are not included separately in the total.

A.2.7.2 New Data and Updated Analysis

The TRT for the North-Central California Coast Recovery Domain has proposed a set of plausible hypotheses, based largely on geography, regarding the population structure of the California Coast Chinook Salmon ESU (Table A.2.7.2), but has concluded that insufficient information exists to discriminate among these hypotheses (NCCC-TRT, *in preparation*). Data are not available for all of the potential populations; only those for which data are available are considered below.

New or updated time series for chinook salmon in this ESU include 1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River; 2) cursory, quasi-systematic spawner surveys on Canon Creek (tributary to the Mad River), Tomki Creek (tributary to the Eel River), and Sprowl Creek (tributary to the Eel River); 3) counts of returning spawners at a weir on Freshwater Creek (tributary to Humboldt Bay). None of these time series is especially suitable for analysis of trends or estimation of population growth rates.

Table A.2.7.2. Plausible hypotheses for independent populations considered by the North Central California Coast TRT. This information is summarized from a working draft report and should be considered as preliminary and subject to revision.

"Lumped"	**"Split"**
Redwood Creek	
Mad River	
Humboldt Bay Tributaries	
Eel River[a]	
	South Fork Eel River
	Van Duzen River
	Middle Fork Eel River
	North Fork Eel River
	Upper Eel River
Bear River	
Mattole River	
Tenmile to Gualala[b]	
Russian River	

[a]Plausible hypotheses regarding the population structure of chinook salmon in the Eel River basin include scenarios ranging from five independent populations (South Fork Eel River, Van Duzen River, Upper Eel River, Middle Fork Eel River, and North Fork Eel River) to a single, strongly structured independent population.

[b]This stretch of the coast comprises numerous smaller basins that drain directly into the Pacific Ocean, some of which appear sufficiently large to support independent populations of chinook salmon. The following hypotheses span much of the range of plausible scenarios: (1) independent populations exist in all basins that exceed a minimum size; (2) independent populations exist only in basins between the Tenmile River and Big River, inclusive, that exceed a minimum size; (3) chinook salmon inhabiting basins along this stretch of coastline exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins, and possibly from larger basins to the north and south; and (4) chinook salmon inhabiting basins between the Tenmile River and Big River, inclusive, exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins in this region and possibly to the north, while other basins to the south only sporadically harbor chinook salmon.

Table A.2.7.3. Geometric means, estimated lambda, and long- and short-term trends for abundance time series in the California Coastal Chinook Salmon ESU.

	5 year Geometric Mean			Trend	
	Rec	Min	Max	Long	Short
Freshwater Creek	22	13	22	0.137 (-0.405, 0.678)	0.137 (-0.405, 0.678)
Mad River					
Canon Creek	73	19	103	0.0102 (-0.106, 0.127)	0.155 (-0.069, 0.379)
Eel River					
Sprowl Creek	43	43	497	-0.096 (-0.157, -0.034)	-0.183 (-0.356, -0.010)
Tomki Creek	61	13	2,233	-0.199 (-0.351, -0.046)	0.294 (0.055, 0.533)

Freshwater Creek—Counts of chinook salmon passing the weir near the mouth of Freshwater Creek, a tributary to Humboldt Bay, provide a proper census of a small (N ~ 20) population of naturally and hatchery-spawned chinook salmon (Figure A.2.7.1). Chinook salmon occupying this watershed may be part of a larger "population" that uses tributaries of Humboldt Bay (NCCC-TRT, *in preparation*). The time series comprises only 8 years of observations, which is too few to draw strong inferences regarding trends. Clearly, the trend is positive, although the role of hatchery production in producing this signal may be significant (Table A.2.7.3; Figure A.2.7.1).

Mad River—Data for naturally spawning fish are available from spawner surveys on Canon Creek, and to a lesser extent on the North Fork Mad River. Only the counts from Canon Creek extend continuously to the present (Figure A.2.7.2a). Due to high variability in these counts, short-term and long-term trends do not differ significantly from zero, although the tendency is toward a positive trend. Due to a hypothesized, but unquantified, effect of interannual variation in water availability on distribution of spawners in the basin, it is not clear whether these data provide any useful information for the population as a whole; however, more sporadic counts from the mainstem Mad River suggest that the estimates from Canon Creek capture gross signals, and support the hypothesis of a recent positive trend in abundance (Figure A.2.7.2b).

Eel River—The Eel River plausibly harbors anywhere from one to five independent populations (NCCC-TRT, *in prep.*, Table A.2.7.2). Three current time series provide information for the population(s) that occupy this basin: 1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River (Figure A.2.7.3a); 2) spawner surveys on Sprowl Creek (tributary to the Eel River) (Figure A.2.7.3b); and 3) spawner surveys on Tomki Creek (tributary to the Eel River) (Figure A.2.7.3c). These data are not especially suited to rigorous analysis of population status for a number of reasons, and sophisticated analyses were not pursued.

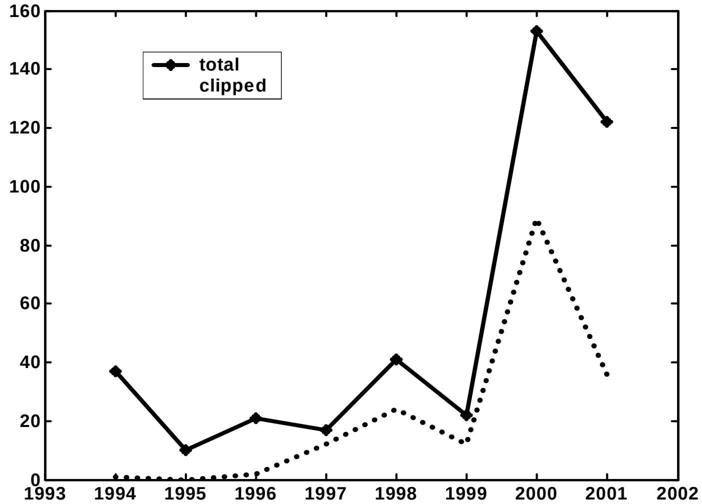


Figure A.2.7.1. Counts of chinook salmon at the weir on Freshwater Creek.

a **b**

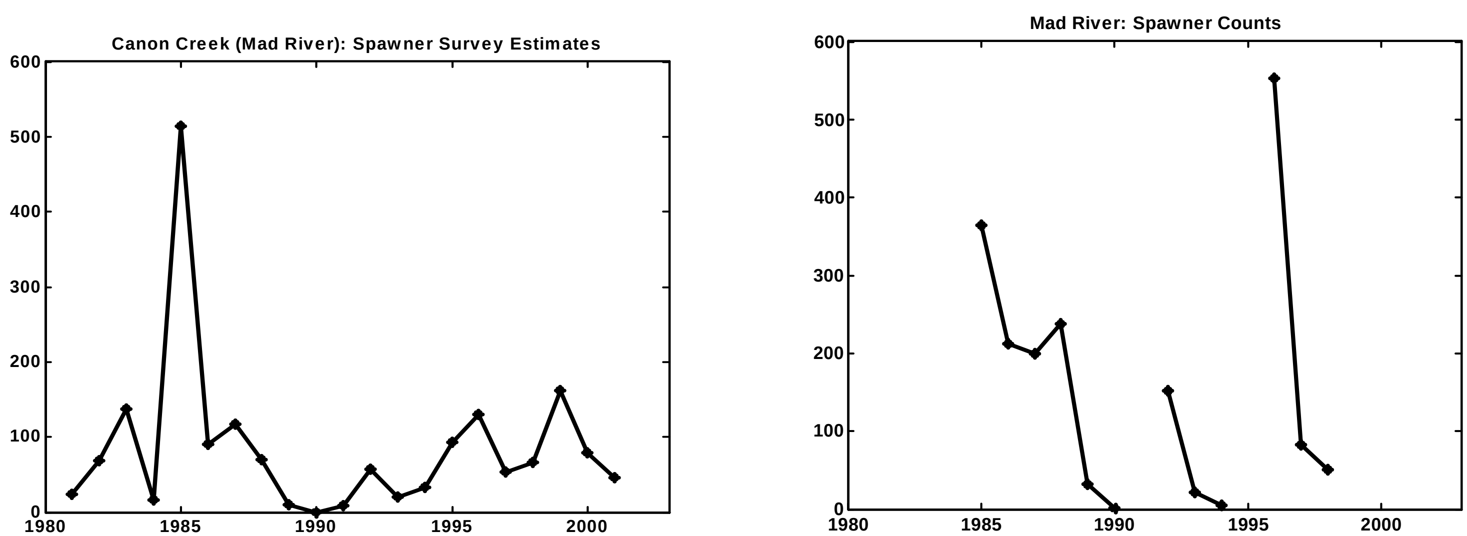


Figure A.2.7.2. Abundance time series for chinook salmon in portions of the Mad River basin. (a) spawner counts on Canon Creek; and (b) spawner counts on portions of the mainstem Mad River.

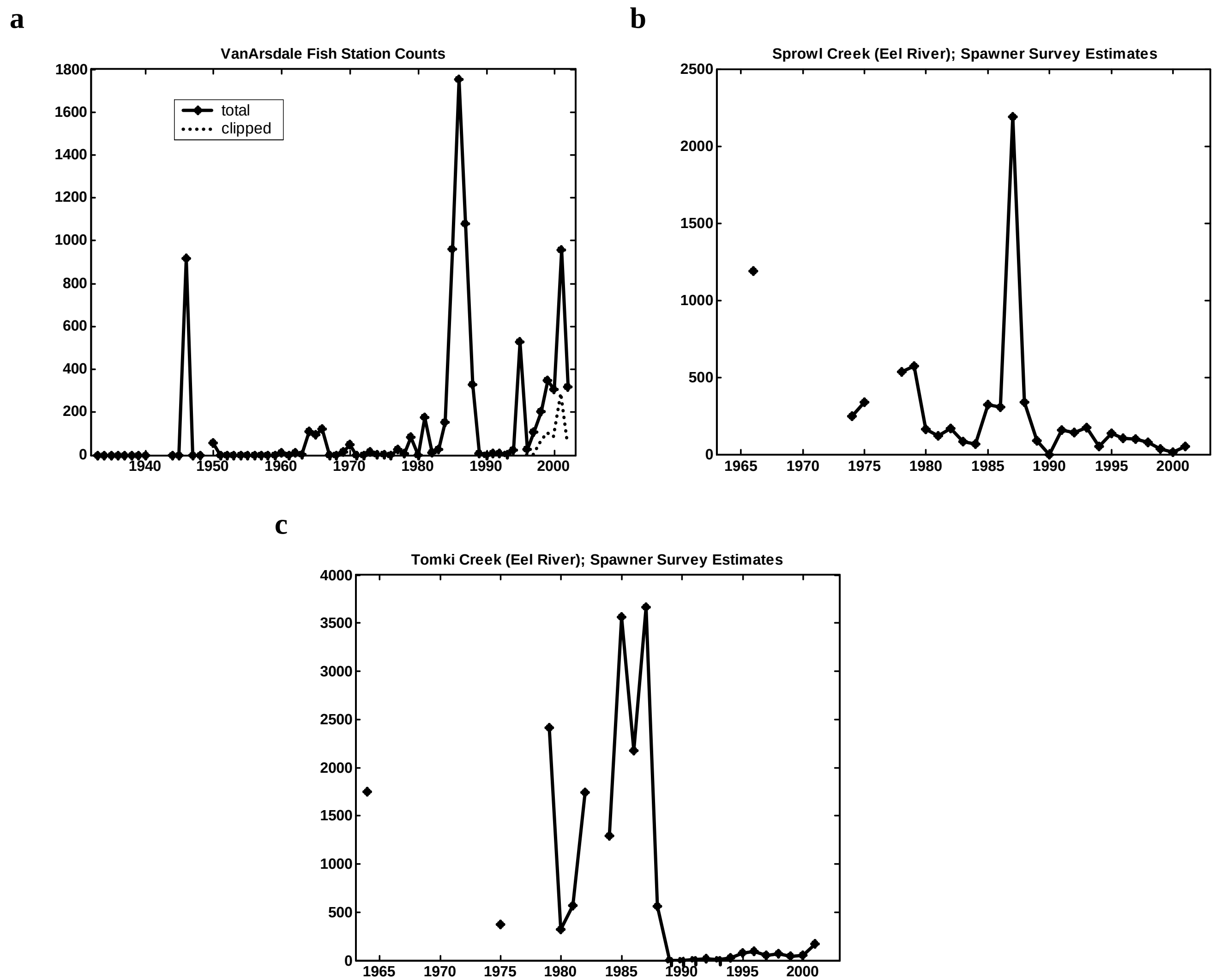


Figure A.2.7.3. Abundance time series for chinook salmon in portions of the Eel River basin. (a) counts of chinook salmon at Van Arsdale Fish Station at the upstream terminus of anadromous access on the mainstem Eel River; (b) estimates of spawner abundance based on spawner surveys and additional data from Sprowl Creek; and (c) estimates of spawner abundance based on spawner surveys and additional data from Tomki Creek.

Inferences regarding population status drawn from the time series of counts of adult chinook salmon reaching Van Arsdale Fish Station (VAFS) are weakened by two characteristics of the data. First, adult salmon reaching VAFS include both naturally and hatchery-spawned fish, yet the long-term contribution of hatchery production to the spawner population is unknown and may be quite variable due to sporadic operation of the egg take-and-release programs since the mid-1970s. Second, and perhaps more importantly, it is not clear what counts of natural spawners at VAFS indicate about the population or populations of chinook salmon in the Eel River. As a weir count, measurement error is expected to be small for these counts. However, very little spawning habitat exists above VAFS, which sits just below the Cape Horn dam on the Eel River, which suggests that counts made at VAFS represent the upper edge of the spawners' distribution in the Upper Eel River. Spawner access to VAFS and other headwater habitats in the Eel River basin is likely to depend strongly on the timing and persistence of suitable river flow, which suggests that a substantial component of the process error in these counts is not due to population dynamics. For these reasons, no statistical analysis of these data was pursued.

Additional data for the Eel River population or populations are available from spawner surveys from Tomki and Sprowl Creeks, which yield estimates of abundance based on 1) quasi-systematic index site spawner surveys that incorporate mark-recapture of carcasses and 2) additional so-called "compatible" data from other surveys. Analysis for Sprowl Creek indicates negative long-term and short-term trends; similar analysis indicates a long-term decline and short-term increase for Tomki Creek (Table A.2.7.3). Caution in interpreting these results is warranted, particularly given the quasi-systematic collection of these data, and the likelihood that these data include unquantified variability due to flow-related changes in spawners' use of mainstem and tributary habitats. In particular, inferences regarding population status based on extrapolations from these data to basin-wide estimates of abundance are expected to be weak and perhaps not warranted.

Mattole River—Recent spawner and redd surveys on the Mattole River and tributaries have been conducted by the Mattole Salmon Group since 1994. The surveys provide useful information on the distribution of salmon and spawning activity throughout the basin. Local experts have used these and ancillary data to develop rough "index" estimates of spawner escapement to the Mattole; however, the intensity and coverage of these surveys has not been consistent, and the resulting data are not suitable for rigorous estimation of abundance (e.g., through area-under-the-curve analysis).

Russian River—No long-term, continuous time series are available for sites in the Russian River Basin, but sporadic estimates based on spawner surveys are available for some tributaries. Video-based counts of upstream migrating adult chinook salmon passing a temporary dam near Mirabel on the Russian River are available for 2000-2002. Counts are incomplete, due to technical difficulties with the video apparatus, occasional periods of poor water clarity, occasional overwhelming numbers of fish, and disparities between counting and migration periods; thus, these data represent a minimum count of adult chinook salmon. Counts have exceeded 1,300 fish in each of the last three years (5,465 in 2002); and a rigorous mark-recapture estimate of outmigrant abundance in 2002 exceeded 200,000 (Shawn Chase, Sonoma County Water Agency, *personal communication*). Since chinook salmon have not been produced at the Don Clausen Hatchery since 1997, these counts represent natural production or straying from other systems. No data were available to assess the genetic relationship of these fish to others in this or other ESUs.

Summary—Historical and current information indicates that abundance in putatively independent populations of chinook salmon is depressed in many of those basins where they have been monitored. The relevance of recent strong returns to the Russian River to ESU status are not clear as the genetic composition of these fish is unknown. Reduction in geographic distribution, particularly for spring-run chinook salmon and for basins in the southern portion of the range, continues to present substantial risk. Genetic concerns are reviewed below (Hatchery Information). As for previous status reviews, uncertainty continues to contribute substantially to assessments of risk facing this ESU.

A.2.7.3 Hatchery Information

Hatchery stocks that are being considered for inclusion in this ESU are: 1) Mad River Hatchery; 2) hatchery activities of the Humboldt Fish Action Council on Freshwater Creek; 3) Yager Creek Hatchery operated by Pacific Lumber Company; 4) Redwood Creek Hatchery; 5) Hollow Tree Creek Hatchery; 6) Van Arsdale Fish Station; and 6) hatchery activities of the Mattole Salmon Group. Chinook salmon are no longer produced at the Don Clausen hatchery on Warm Springs Creek (Russian River). In general, hatchery programs in this ESU are not oriented toward large-scale production, but rather are small-scale operations oriented at supplementing depressed populations.

Freshwater Creek—This hatchery is operated by Humboldt Fish Action Council and CDFG to supplement and restore natural production in Freshwater Creek. All spawners are from Freshwater Creek; juveniles are marked and hatchery fish are excluded from use as broodstock. Weir counts provide good estimates of the proportion of hatchery- and naturally produced fish returning to Freshwater Creek (30%-70% hatchery from 1997-2001); the contribution of HFAC production to spawning runs in other streams tributary to Humboldt Bay is unknown.

Mad River—Recent production from this hatchery has been based on small numbers of spawners returning to the hatchery. There are no estimates of naturally spawning chinook salmon abundance available for the Mad River to determine the contribution of hatchery production to chinook salmon in the basin as a whole. Broodstock has generally been drawn from chinook salmon returning to the Mad River; however, releases in the 1970s and 1980s have included substantial releases of fish from out-of-basin (Freshwater Creek) and out-of-ESU (Klamath-Trinity and Puget Sound).

Eel River—Four hatcheries, none of which are major production hatcheries, contribute to production of chinook salmon in the Eel River Basin: hatcheries on Yager Creek (recent effort: ~12 females spawned per year), Redwood Creek (~12 females), Hollow Tree Creek, and the Van Arsdale Fish Station (VAFS) (~60 males and females spawned). At the first three hatcheries, broodstock is selected from adults of non-hatchery origin; at VAFS, broodstock includes both natural and hatchery-origin fish. In all cases, however, insufficient data on naturally spawning chinook salmon are available to estimate the effect of hatchery fish on production or other characteristics of naturally spawning chinook salmon in the Eel River Basin. Since 1996, all fish released from VAFS have been marked. Subsequent returns indicate that approximately 30% of the adult chinook salmon trapped at VAFS are of hatchery origin. It is not clear what these numbers indicate about hatchery contributions to the population of fish spawning below VAFS.

Mattole River—The Mattole Salmon Group has operated a small hatchbox program since 1980 (current effort: ~40,000 eggs from ~10 females) to supplement and restore chinook salmon and other salmonids in the Mattole River. All fish are marked, but no rigorous estimate of hatchery contributions to adult escapement is possible. Hatchery-produced outmigrants comprised approximately 17.3% (weighted average) of outmigrants trapped during 1997, 1998, and 2000 (Mattole Salmon Group 2000, Five Year Management Plan for Salmon Stock Rescue Operations 2000-2001 through 2004-2005 Seasons). Trapping efforts did not fully span the period of natural outmigration, so this figure may overerestimate the contribution of hatchbox production to total production in the basin.

Russian River—Production of chinook salmon at the Don Clausen (Warm Springs Hatchery) ceased in 1997 and had been largely ineffective for a number of years prior to that. Recent returns of chinook salmon to the Russian River stem from natural production, and possibly from fish straying from other basins, including perhaps Central Valley stocks.

Summary

Artificial propagation of chinook salmon in this ESU remains at relatively low levels. No putatively independent populations of chinook salmon in this ESU appear to be entirely dominated by hatchery production, although proportions of hatchery fish can be quite high where natural escapement is small and hatchery production appears to be successful (e.g., Freshwater Creek). It is not clear whether current hatcheries pose a risk or offer a benefit to naturally spawning populations. Extant hatchery programs are operated under guidelines designed to minimize genetic risks associated with artificial propagation, and save for historical inputs to the Mad River Hatchery stock, do not appear to be at substantial risk of incorporating out-of-basin or out-of-ESU fish. Thus, it is likely that artificial propagation and degradation of genetic integrity continue to not represent a substantial conservation risk to the ESU. Categorizations of hatchery stocks in the California Coastal chinook salmon ESU (SSHAG 2003) can be found in Appendix A.5.1.

A.2.7.4 Comparison with Previous Data

Few new data, and few new datasets were available for consideration, and none of the recent data contradict the conclusions of previous status reviews. Chinook salmon in the Coastal California ESU continue to exhibit depressed population sizes relative to historical abundances; this is particularly true for spring-run chinook salmon, which may no longer be extant anywhere within the range of the ESU. Evaluation of the significance of recent potential increases in abundance of chinook salmon in the Russian River must weigh the substantial uncertainty regarding the genetic relatedness of these fish to others in the northern part of the ESU.

Harvest rates are not explicitly estimated for this ESU; however, it is likely that current restrictions on harvest of Klamath River fall-run chinook salmon maintain low ocean harvest of chinook salmon from the California Coastal ESU (PFMC 2002a, b). Potential changes in age-structure of chinook salmon populations (e.g., Hankin et al. 1993) and associated risk has not been evaluated for this ESU.

No information exists to suggest new risk factors, or substantial effective amelioration of risk factors noted in the previous status reviews save for recent changes in ocean conditions. Recent favorable ocean conditions have contributed to apparent increases in abundance and distribution for a number of anadromous salmonids, but the expected persistence of this trend is unclear.

A.2.8 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

Primary contributor: Steven T. Lindley (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.8.1 Summary of Previous BRT Conclusions

The status of chinook salmon coastwide was formally assessed in 1998 (Myers et al. 1998); however, NMFS had previously recognized Sacramento River winter-run chinook as a "distinct population segment" under the ESA (NMFS 1987).

Summary of major risk factors and status indicators

Historically, winter-run chinook salmon were dependent on access to spring-fed tributaries to the upper Sacramento River that stayed cool during the summer and early fall. Adults enter freshwater in early winter and spawn in the spring and summer. Juveniles rear near the spawning location until at least the fall, when water temperatures in lower reaches are suitable for migration. Winter-run chinook salmon were abundant and comprised populations in the McCloud, Pit, and Little Sacramento, with perhaps smaller populations in Battle Creek and the Calaveras River. On the basis of commercial fishery landings in the 1870s, Fisher (1994) estimated that the total run size of winter-run chinook salmon may have been 200,000 fish.

The most obvious challenge to winter-run chinook salmon was the construction of Shasta Dam, which blocked access to the entire historic spawning habitat. It was not expected that winter-run chinook salmon would survive this habitat alteration (Moffett 1949). Cold-water releases from Shasta, however, created conditions suitable for winter-run chinook salmon for roughly 100 km downstream from the dam. Presumably, there were several independent populations of winter-run chinook salmon in the Pitt, McCloud, and Little Sacramento Rivers, and various tributaries to these rivers, such as Hat Creek and the Fall River. These populations merged to form the present single population. If there ever were populations in Battle Creek and the Calaveras River, they have been extirpated.

In addition to having only a single extant population dependent on artificially created conditions, winter-run chinook salmon face numerous other threats. Chief among these is small population size—escapement fell below 200 fish in the 1990s. Population size declined monotonically from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival. There are questions of genetic integrity due to winter-run chinook salmon having passed through several bottlenecks in the 20th century. Other threats include inadequately screened water diversions, predation at artificial structures and by non-native species, pollution from Iron Mountain Mine (among other sources), adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures (e.g., Red Bluff Diversion Dam), and vulnerability to drought.

Previous BRT conclusions

The chinook salmon BRT spent little time considering the status of winter-run chinook salmon, because winter-run chinook salmon were already listed as endangered at the time of previous BRT meetings.

Listing status

Winter-run chinook salmon were listed as Threatened in 1990 and reclassified as Endangered 1994.

A.2.8.2 New Data and Updated Analyses

Viability assessments

Two studies have been done on the population viability of Sacramento River winter-run chinook salmon. Botsford and Brittnacher (1998), in a paper that is part of the draft recovery plan, developed de-listing criteria using a simple age-structured, density-independent model of spawning escapement. They concluded, on the basis of the 1967-1995 data, that winter-run chinook salmon were certain to fall below the quasi-extinction threshold of three consecutive spawning runs with less than 50 females.

Lindley and Mohr (2003) developed a slightly more complex Bayesian model of winter-run chinook salmon spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures initiated in 1989. This model, due to its allowance for the growth rate change, its accounting for parameter uncertainty, and use of newer data (through 1998), suggested a lower but still biologically significant expected quasi-extinction probability of 28%.

Draft recovery plan

The draft recovery plan for winter-run chinook salmon (NMFS 1997) provides a comprehensive review of the status, life history, habitat requirements, and risk factors of winter-run chinook salmon. It also provides a recovery goal: an average of 10,000 females spawners per year and a $\lambda \geq 1.0$ calculated over 13 years of data (assuming a certain level of precision in spawning escapement estimates).

New abundance data

The winter-run chinook salmon spawning run has been counted at Red Bluff Diversion Dam (RBDD) fish ladders since 1967. Escapement has been estimated with a carcass survey since 1996. Through the mid-1980s, the RBDD counts were very reliable. At that time, changes to the dam operation were made to alleviate juvenile and adult passage problems. Now, only the tail end of the run (about 15% on average) is forced over the ladders, greatly reducing the accuracy of the RBDD counts. The carcass mark-recapture surveys were initiated to improve escapement estimates. The two measures are in very rough agreement, and there are substantial problems with both estimates, making it difficult to choose one as more reliable than the other. One problem with the carcass-based estimate is the estimation of the probability of capturing carcasses—it appears that the probability of initial carcass recovery depends strongly on the sex of the fish, the size of the fish, and possibly on whether it has been previously recovered. In the winter-run chinook salmon carcass surveys, a high ratio of female to males is observed (e.g., Snider et al. 1999), and several studies of salmon carcass recovery have noted that females are recovered with a higher probability than males, presumably because of the different behavior of males and females (e.g., Shardlow et al. 1986 and references therein). In spite of these problems, both abundance measures suggest that the abundance of winter-run chinook salmon is increasing. Based on the RBDD counts, the winter-run chinook salmon population has been growing rapidly since the early 1990s (Figure A.2.8.1), with a short-term trend of 0.26 (Table A.2.8.1). On the population growth rate-population size space, the winter-run chinook salmon population has a somewhat low population growth and moderate size compared to other Central Valley salmonid populations (Figure A.2.8.2).

Table A.2.8.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals. Results for other populations are shown for comparison.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)
Sacramento River steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	NA

Winter-run chinook salmon may be responding to a number of factors, including wetter-than-normal winters, changes in ocean harvest regulations since 1995 significantly reducing harvest, changes in RBDD operation, improved temperature management on the Upper Sacramento (including installation of a cold-water release device on Shasta Dam), water quality improvements due to remediation of Iron Mountain Mine discharges, changes in operations of the state and federal water projects, and a variety of other habitat improvements. While the status of winter-run chinook salmon is improving, there is only one winter-run chinook salmon population and it is dependent on cold-water releases of Shasta Dam, which could be vulnerable to a prolonged drought. The recent 5-year geometric mean is only 3% of the maximum post-1967 5-year geometric mean.

The RBDD counts are suitable for modeling as a random-walk-with-drift (also known as the "Dennis model" [Dennis et al. 1991]). In the RWWD model, population growth is described by exponential growth or decline:

$$N_{t+1} = N_t \exp(\mu + \eta_t), \quad (1)$$

where N_t is the population size at time t, μ is the mean population growth rate, and η_t is a normal random variable with mean=0 and variance = σ^2_p.

Table A.2.8.2. Parameter estimates for the constant-growth and step-change models applied to winter-run chinook salmon. Numbers in parentheses indicate 90% confidence intervals.

	Model	
parameter	**constant μ**	**step change μ**
μ	-0.085	-0.214
	(-0.181, 0.016)	(-0.322, -0.113)
δ	NA	0.389
	NA	(0.210, 0.574)
σ^2_p	0.105	0.056
	(0.094, 0.122)	(0.046, 0.091)
σ^2_m	0.0025	0.011
	(2.45E-6, 0.0126)	(3.92E-6, 0.022)
P_{100}(ext)[a]	0.40	0.003
	(0.00, 0.99)	(0.0, 0.0)

[a] Probability of extinction (pop. size < 1 fish) within 100 years.

The RWWD model, as written in Equation 1, ignores measurement error. Observations (y_t) can be modeled separately,

$$y_t = N_t \exp(\varepsilon_t), \quad (2)$$

where ε_t is a normal random variable with mean = 0 and variance = σ^2_m. Equations 1 and 2 together define a state-space model that, after linearizing by taking logarithms, can be estimated using the Kalman filter (Lindley in press).

A recent analysis of the RBDD data (Lindley and Mohr 2003) indicated that the population growth since 1989 was higher than in the preceding period. For this reason, I fit two forms of the RWWD model—one with a fixed growth rate (constant-growth model) and another with a growth rate with a step-change in 1989, when conservation actions began (step-change model, $\mu_t = \mu$ for $t < 1989$, $\mu_t = \mu + \delta$ for $t \geq 1989$). In both cases, a 4-year running sum was applied to the spawning escapement data to form a total population estimate (Holmes 2001). Results of model fitting are shown in Table A.2.8.2. The constant-growth model satisfies all model diagnostics, although visual inspection of the residuals shows a strong tendency to under-predict abundance in the most recent 10 years. The residuals of the step-change model fail the Shapiro-Wilks test for normality; the residuals look truncated on the positive side, meaning that good years are not as extreme as bad years. Winter-run chinook salmon growth rate might be better modeled as a mixture between a normal distribution and another distribution reflecting near-catastrophic population declines caused by episodic droughts.

According to Akaike's information criterion (AIC), the step-change model is a much better approximation to the data than the constant population growth rate model, with an AIC difference of 9.61 between the two models (indicating that the data provide almost no support for the constant-growth model). The step-change model suggests the winter-run chinook salmon population currently has a λ of 1.21, while for the constant population growth rate model, $\lambda = 0.97$[5]. The extinction risks predicted by the two models are extremely different: winter-run chinook salmon have almost no risk of extinction if the apparent recent increase in λ holds in the future, but are certain to go extinct if the population grows at its average rate, with a most likely time of extinction being 100 years. While it would be dangerous to assume that recent population growth will hold indefinitely, it does appear that the status of winter-run chinook salmon is improving.

Harvest impacts

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of winter-run chinook salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena, and that fish from the Central Valley are caught in Oregon fisheries. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon.. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and concurrent increases in other chinook salmon runs in the Central Valley.

Because they mature before the ocean fishing season, winter-run chinook salmon should have lower harvest rates than fall-run chinook salmon, if they have similar age-at-maturity. At the time of the last status review, the only information on the harvest rate of winter-run chinook salmon came from a study conducted in the 1970s. Hallock and Fisher (1985) reported that the average catch/(catch+escapement) for the 1969-71 broodyears was 0.40 for the ocean fishery. For the 1968-1975 period, freshwater sport fisheries caught an average of 10% of the winter chinook salmon run.

The recent release of significant numbers of ad-clipped winter-run chinook salmon provides new, but limited, information on the harvest of winter-run chinook salmon in coastal recreational and troll fisheries. The Pacific Fisheries Management Council's Sacramento River Winter and Spring Chinook salmon Workgroup (SRWSCW) conducted a cohort reconstruction of the 1998 broodyear (PFMC 2003). Winter-run chinook salmon are mainly vulnerable to ocean fisheries as 3-year olds. SRWSCW calculated, on the basis of 123 coded-wire-tag

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[5]In this section of the document, λ is defined as $\exp(\mu + \sigma^2_p / 2)$, the *mean* annual population growth rate.

recoveries, that the ocean fishery impact rate on 3-year-olds was 0.23, and the in-river sport fishery impact rate was 0.24. These impacts combine to reduce escapement to 100*(1-0.23)*(1-0.24) = 59% of what it would have been in the absence of fisheries, assuming no natural mortality during the fishing season. The high estimated rate of harvest in the river sport fishery, which arises from the recovery of eight coded-wire tags, was a surprise because salmon fishing is closed from January 15 to July 31 to protect winter-run chinook salmon. The tags were recovered in late December/early January, at the tail end of the fishery for late-fall-run chinook salmon.. The estimate of river sport fishery impact is much less certain than the ocean fishery impact estimate because of the lower number of tag recoveries, less rigorous tag sampling, and larger expansion factors. The California Fish and Game Commission is moving forward with an emergency action to amend sport fishing regulations to ban retention of salmon caught in river sport fisheries on January 1 rather than January 15. Had such regulations been in place in 1999/2000, the freshwater harvest rate would have been 20% of that observed.

New hatchery information

Livingston Stone National Fish Hatchery (LSNFH) was constructed at the base of Shasta Dam in 1997, with the sole purpose of helping to restore natural production of winter-run chinook salmon. LSNFH was designed as a conservation hatchery with features intended to overcome the problems of CNFH (better summer water quality, natal water source). All production is ad-clipped. Each individual considered for use as broodstock is genotyped to ensure that it is a winter-run chinook salmon. No more than 10% of the broodstock is composed of hatchery-origin fish, and no more than 15% of the run is taken for broodstock, with a maximum of 120 fish. Figure 3 shows the number of winter-run chinook salmon released by CNFH/LSNFH; Figure 4 shows the number of winter-run chinook salmon spawners taken into the hatchery.

A.2.8.3 New Comments

The California State Water Contractors, the San Luis and Delta-Mendota Water Authority, and the Westlands Water District recommend that the listing status of winter-run chinook salmon be changed from Endangered to Threatened. They base this proposal on the recent upturn of adult abundance, recently initiated conservation actions (restoration of Battle Creek, ocean harvest reductions, screening of water diversions, remediation of Iron Mountain Mine, and improved temperature control), and a putative shift in ocean climate in 1999.

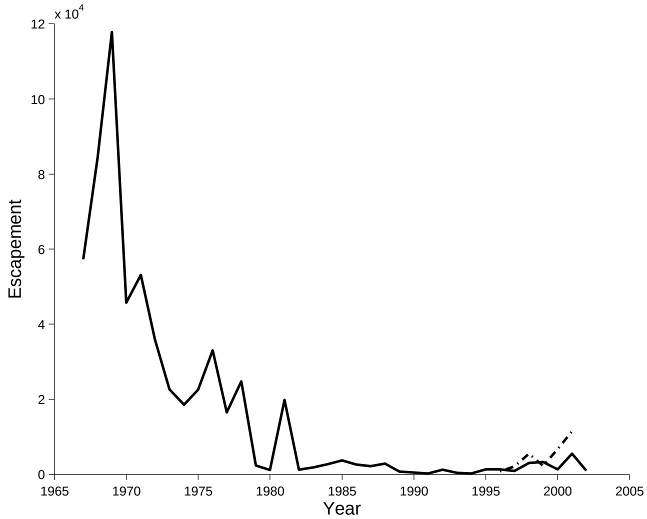

Figure A.2.8.1. Estimated winter-run chinook spawner abundance as determined by RBDD fish ladder (solid line) and carcass mark-recapture (dashed line).

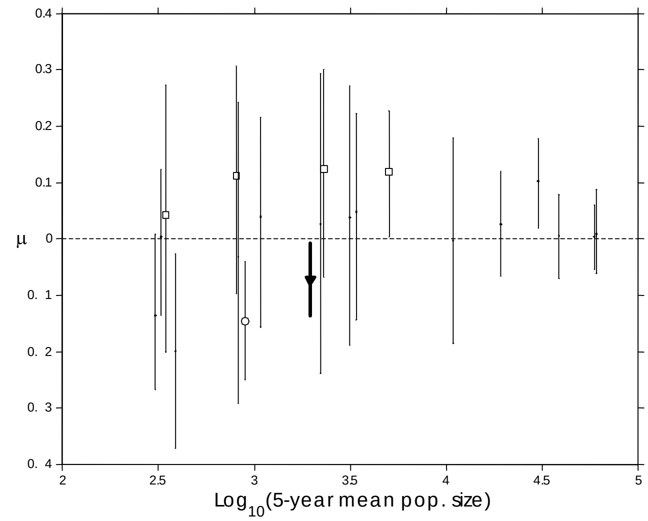

Figure A.2.8.2. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; open squares- spring chinook; filled triangle- winter-run chinook; small black dots- other chinook stocks. Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log(\lambda)$.)

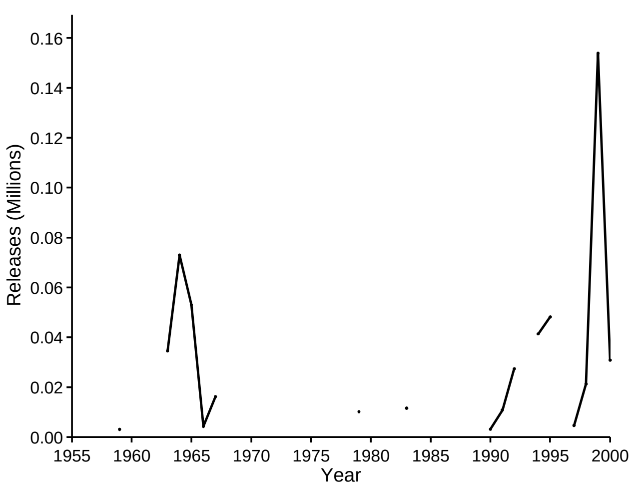

Figure A.2.8.3. Number of juvenile winter-run chinook released by Coleman and Livingston Stone National Fish Hatcheries.

Figure A.2.8.4. Number of adult winter-run chinook collected for broodstock by Coleman and Livingston Stone National Fish Hatcheries.

A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

Primary contributor: Steven T. Lindley (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.9.1. Summary of Previous BRT Conclusions

The status of Central Valley spring-run chinook salmon was formally assessed during a coastwide status review (Myers et al. 1998). In June 1999, a BRT convened to update the status of this ESU by summarizing information and comments received since the 1997 status review and presenting BRT conclusions concerning four deferred chinook salmon ESUs (NMFS 1999).

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring-run chinook salmon fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring-run chinook salmon program. Like most spring-run chinook salmon, CV spring-run chinook salmon require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500 m elevation, and most such habitat in the CV is now upstream of impassable dams (Figure A.2.9.1). Only three wild populations of spring-run chinook salmon with consistent spawning runs (on Mill, Deer and Butte Creeks, tributaries to the Lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on early gill-net fishery catches). The Upper Sacramento River supports a small spring-run population, but population status is poorly documented and the degree of hybridization with fall-run chinook salmon is unknown. Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain. The Feather River population is dependent on Feather River Hatchery (FRH) production, and may be hybridized with fall-run chinook salmon. Little is known about the status of the spring-run chinook salmon population on the Yuba River other than it appears to be small.

In addition to outright loss of habitat, CV spring-run chinook salmon must contend with the widespread habitat degradation and modification of their rearing and migration habitats in the natal stream, the Sacramento River, and the delta. The natal tributaries do not have large impassable dams like many Central Valley streams, but they do have many small hydropower dams and water diversions that, in some years, have greatly reduced or eliminated in-stream flows during spring-run migration periods. Problems in the migration corridor include unscreened or inadequately screened water diversions, predation by non-native species, and excessively high water temperatures.

The Feather and Yuba Rivers contain populations that are thought to be significantly influenced by the FRH spring-run chinook salmon stock. The FRH spring-run chinook salmon program releases its production far downstream of the hatchery[6], causing high rates of straying (CDFG 2001). There is concern that fall-run and spring-run chinook salmon have hybridized in the hatchery. The BRT viewed FRH as a major threat to the genetic integrity of the remaining wild spring-run chinook salmon populations.

[6] In 2003, CDFG plans to release half of its spring-run chinook production into the river, half into San Pablo Bay.

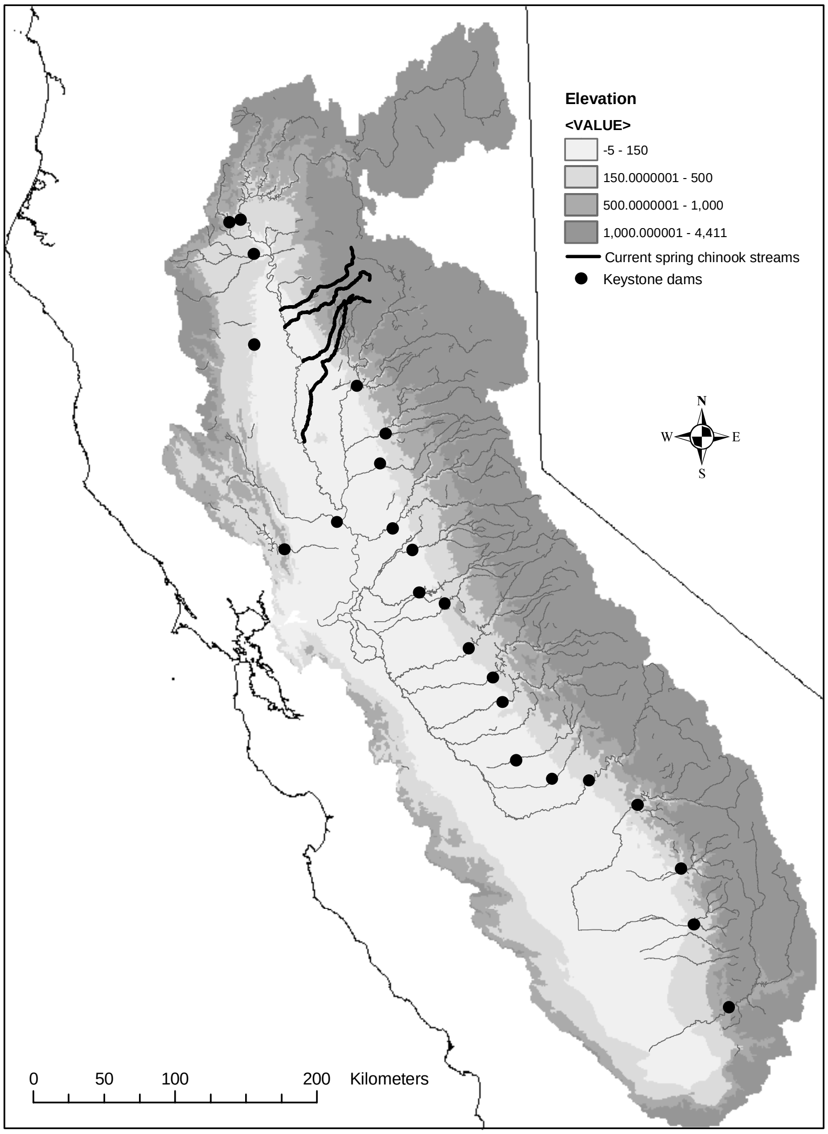

Figure A.2.9.1. Map of Central Valley showing the locations of spring-run chinook salmon populations with consistent runs, plus Big Chico Creek, which in recent years has had a small run. These populations are found in the only watersheds with substantial accessible habitat above 500 m elevation. Keystone dams are the lowest impassable dams on a river or stream.

Previous BRT conclusions

In the original chinook salmon status review, a majority of the BRT concluded that the CV spring-run chinook salmon ESU was in danger of extinction (Myers et al. 1998). Listing of this ESU was deferred, and in the status review update, the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (NMFS 1999). A major reason for this shift was data indicating that a large run of spring-run chinook salmon on Butte Creek in 1998 was naturally produced, rather than strays from FRH.

Listing status

Central Valley spring-run chinook salmon were listed as threatened in 1999. Naturally spawning spring-run chinook salmon in the Feather River were included in the listing, but the Feather River Hatchery stock of spring-run chinook salmon was excluded.

A.2.9.2 New Data and Updated Anlayses

Status assessments

In 1998, CDFG reviewed the status of spring-run chinook salmon in the Sacramento River drainage in response to a petition to list these fish under the California Endangered Species Act (CESA) (CDFG 1998). CDFG concluded that spring-run chinook salmon formed an interbreeding population segment distinct from other chinook salmon runs in the Central Valley. CDFG estimated that peak run sizes might have exceeded 600,000 fish in the 1880s, after substantial habitat degradation had already occurred. They blame the decline of spring-run chinook salmon on the early commercial gillnet fishery, water development that blocked access to headwater areas, and habitat degradation. Current risks to the remaining populations include continued habitat degradation related to water development and use, and the operation of FRH. CDFG recommended that Sacramento River spring-run chinook salmon be listed as threatened under the CESA.

Population structure

There are preliminary results for two studies of spring-run chinook salmon population structure. Two important insights are provided by these data sets. First, CV spring-run chinook salmon do not appear to be monophyletic, yet wild CV spring-run chinook salmon populations from different basins are more closely related to each other than to fall-run chinook salmon from the same basin. Second, neither Feather River natural (FR) or Feather River Hatchery (FRH) spring-run chinook salmon are closely related to any of the three wild populations although they are closely related to each other and to CV fall-run chinook salmon.

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring-run chinook salmon are not closely related to sympatric fall-run chinook salmon populations or the FRH spring-run chinook salmon stock (Figure A.2.9.2). FRH spring-run chinook salmon, putative Feather River natural spring-run chinook salmon, and Yuba River spring-run chinook salmon fell into a large cluster composed mostly of natural and hatchery fall-run chinook salmon.

Dennis Hedgecock and colleagues, using 12 microsatellite markers, showed that there are two distinct populations of chinook salmon in the Feather River (Hedgecock 2002). One population is formed by early-running ("spring-run") chinook salmon, the other by late running fish ("fall-run"). Once run timing was accounted for, hatchery and naturally spawning fish appear to form a homogeneous population. The Feather River spring-run population is most closely related to FR fall-run (F_{st}=0.010) and to Central Valley fall-run chinook salmon (F_{st}=0.008), and is distinct from spring-run chinook salmon in Deer, Mill (F_{st}=0.016), and Butte (F_{st}=0.034) Creeks. Figure A.2.9.3 shows the neighbor-joining tree with Cavalli-Sforza and Edwards chord distances and unweighted pair-group method arithmetic averaging.

At least two hypotheses could explain the Feather River observations:

1. An ancestral Mill/Deer/Butte-type spring-run chinook salmon was forced to hybridize with the fall-run chinook salmon, producing an intermediate form.
2. The ancestral Feather River spring-run chinook salmon had a common ancestor with the Feather River fall-run chinook salmon, following the pattern seen in Klamath chinook salmon but different from the pattern seen in Deer, Butte, and Mill Creeks. The FR and FRH populations have merged.

Hedgecock argues against the first hypothesis. Feather River fish cluster well within Central Valley fall-run chinook salmon rather than between Mill/Deer/Butte spring-run chinook salmon and Central Valley fall-run chinook salmon, as would be expected under hypothesis 1. Furthermore, there is no evidence from linkage disequilibria that FR spring-run and FR fall-run populations are hybridizing, i.e., these populations are reproductively isolated. It is perhaps not surprising that Feather River spring-run chinook salmon might have a different ancestry than spring-run chinook salmon in Mill, Deer, and Butte Creeks, because the Feather River is in a different ecoregion.

Regardless of the cause of the genetic patterns described above, these new data do not support the current configuration of the CV spring-run chinook salmon ESU. Feather River spring-run chinook salmon do not appear to share a common ancestry or evolutionary trajectory with other spring-run chinook salmon populations in the Central Valley. They share the designation of "spring-run" chinook salmon, and indeed, the Feather River and FRH have a chinook salmon spawning run that starts much earlier than other Sacramento basin rivers. There is no longer a distinct bimodal distribution to run timing, however, and substantial fractions of fish released as FRH spring-run chinook salmon have returned during the fall-run chinook salmon period (and vice versa) (CDFG 1998). If FR and FRH spring-run chinook salmon are retained in the CV spring-run chinook salmon ESU, then the ESU configuration of the CV fall-late-fall-run chinook salmon ESU (among several others) should be reconsidered for the sake of consistency, because late-fall-run chinook salmon are more distinct genetically and arguably as distinct in terms of life history as FRH spring-run chinook salmon.

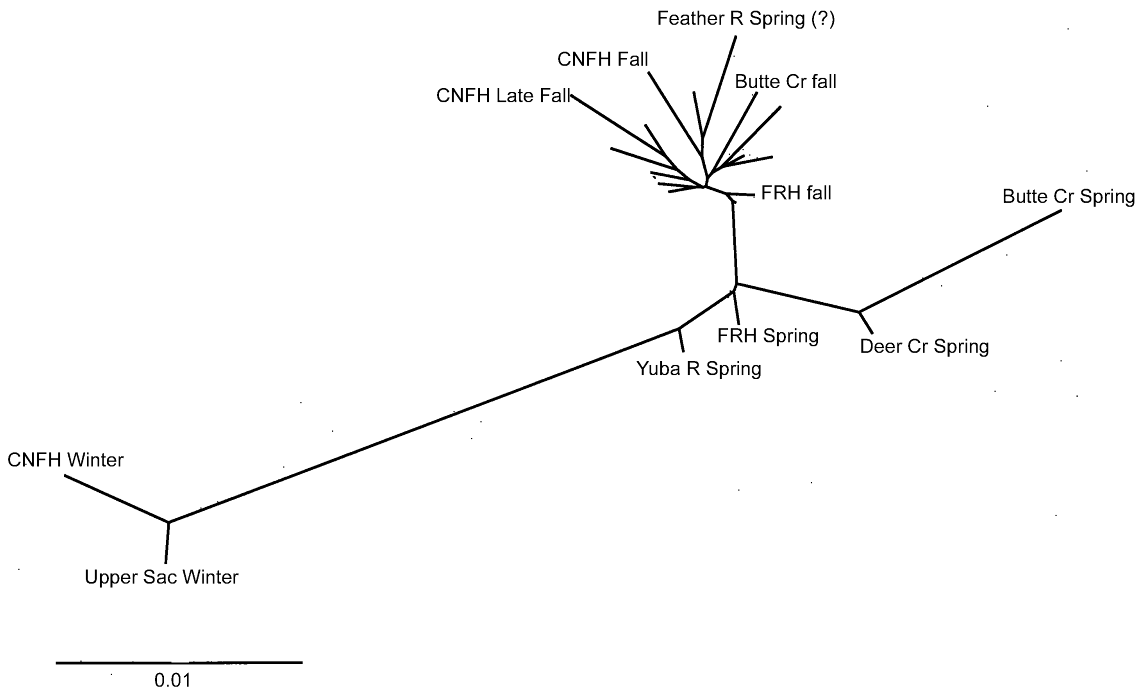

Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall-run chinook salmon populations. The "?" after Feather R Spring indicates that CDFG biologists are not certain that the fish collected for that sample are truly spring-run chinook salmon.

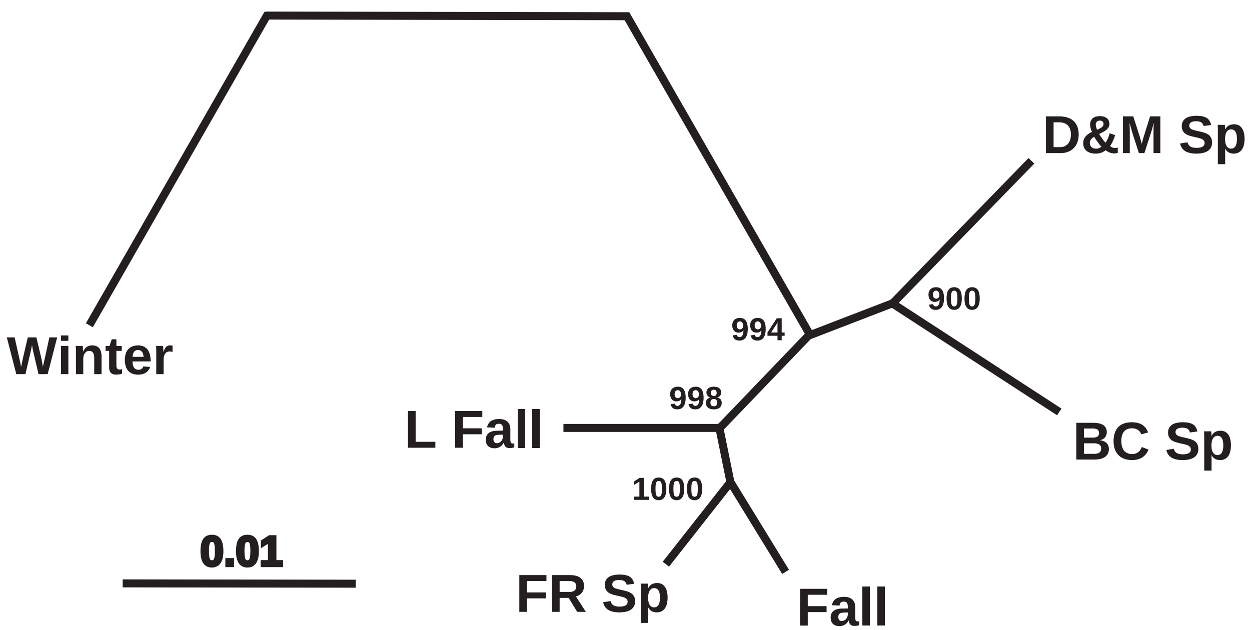

Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring-run chinook salmon; L Fall-run = late-fall-run chinook salmon; Winter = winter-run chinook salmon. The tree was constructed using Cavalli-Sforza and Edwards measure of genetic distance and the unweighted pair-group method arithmetic averaging. Figure from Hedgecock (2002).

Historic habitat loss

Yoshiyama and colleagues detailed the historic distribution of CV spring-run chinook salmon. Yoshiyama et al. (2001) estimated that 72% of salmon spawning and rearing habitat has been lost in the Central Valley. This figure is for fall-run as well as spring-run chinook salmon, so the amount of spring-run chinook salmon habitat lost is presumably higher because spring-run chinook salmon spawn and rear in higher elevations, areas more likely to be behind impassable dams. They deem the 95% loss estimate of CDFG (Reynolds et al. 1993) as "perhaps somewhat high but probably roughly accurate."

Life history

CDFG recently began intensive studies of Butte Creek spring-run chinook salmon (Ward et al. 2002). One of the more interesting observations is that while the great majority of spring-run chinook salmon leave Butte Creek as young-of-the-year, yearling outmigrants make up roughly 25% of the ocean catch of Butte Creek spring-run chinook salmon.

Harvest information

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of CV spring-run chinook salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and recent increases in spring-run populations.

Coded-wire tagging of juvenile spring-run chinook salmon in Butte Creek provides some limited information on the ocean distribution of this population; there have not yet been enough tag recoveries for a full cohort reconstruction. Butte Creek spring-run chinook salmon have a more northerly distribution than winter-run chinook salmon (PFMC 2003), with recoveries off of Oregon and in the Klamath Management Zone and Fort Bragg areas. The majority of recoveries have been south of Point Arena.

Abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico Creek spring-run chinook salmon have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate.

The time series for Butte, Deer, and Mill Creeks are barely amenable to simple analysis with the random walk-wth-drift model (Homes 2001, Lindley in press). The data series are short, and inconsistent methods were used until 1992, when a consistent snorkel survey was initiated on Butte and Deer Creeks. The full records for these three systems are analyzed with the knowledge that there may be significant errors in pre-1992 observations. Table A.2.9.1 summarizes the analyses of these time series.

It appears that the three spring-run chinook salmon populations in the Central Valley are growing. The current 5-year geometric means for all three populations are also the maximum 5-year means. All three spring-run chinook salmon populations have long- and short-term $\lambda > 1$ (λ is defined as $\exp(\mu + \sigma^2_p / 2)$—the *mean* annual population growth rate in this document), with lower bounds of 90% confidence intervals generally > 1. Long- and short-term trends are also positive, although some confidence interval lower bounds are negative. CV spring-run chinook salmon have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run chinook salmon populations (Figure A.2.9.5).

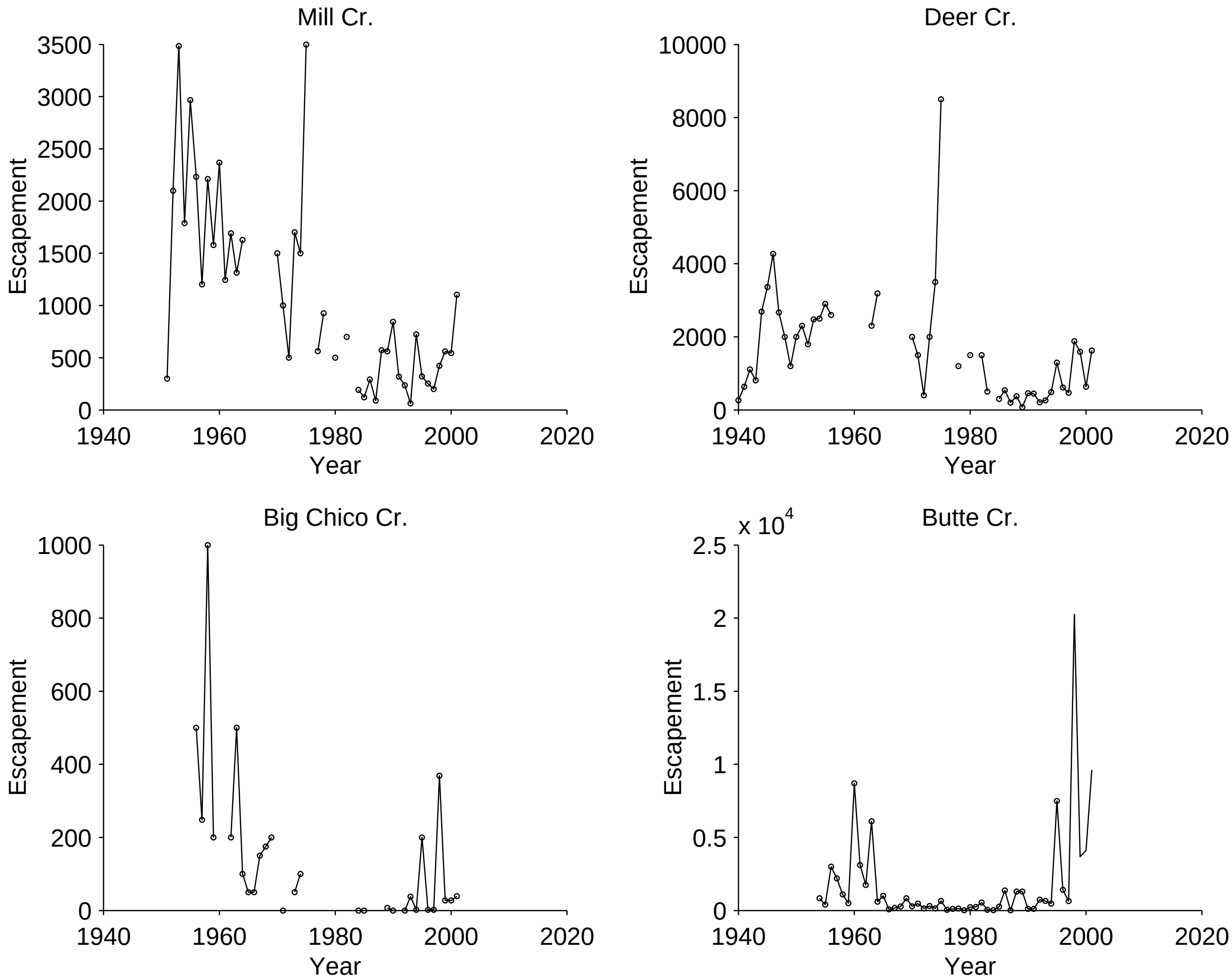

Figure A.2.4. Time series of population abundance for Central Valley spring-run chinook salmon.

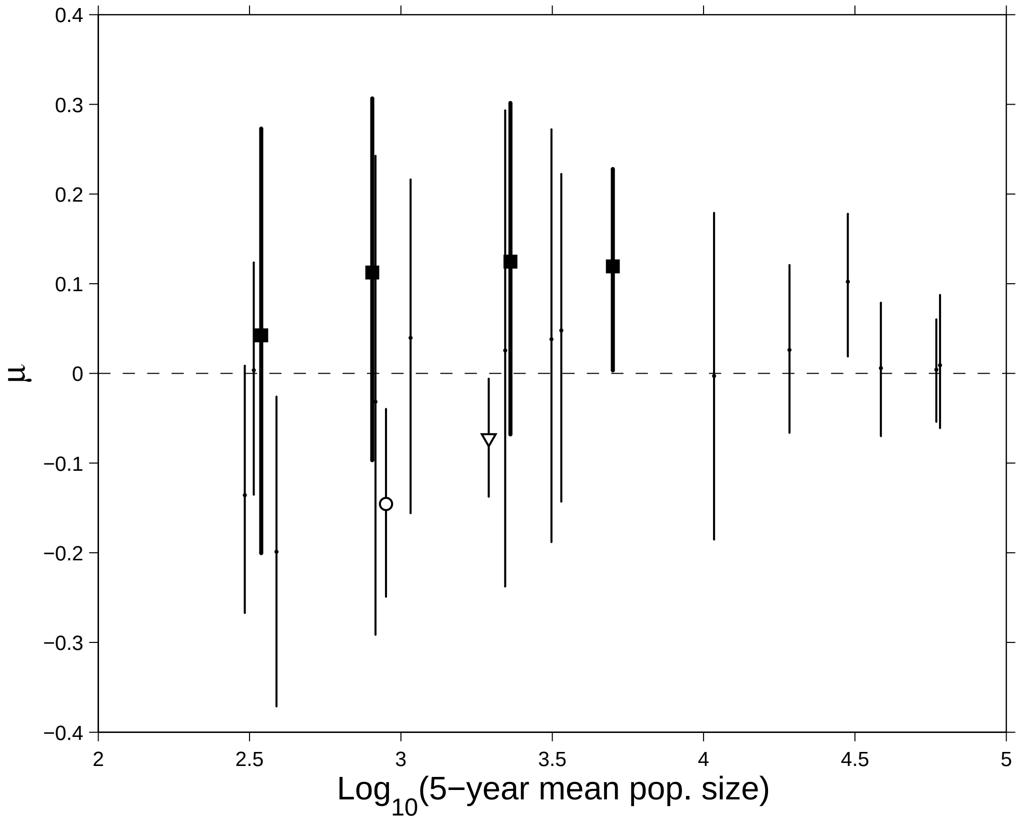

Figure A.2.5. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring-run chinook salmon; open triangle- winter-run chinook salmon; small black dots- other chinook salmon stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log [\lambda]$.)

Table A.2.9.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals.

Population	**5-yr mean**	**5-yr min**	**5-yr max**	**λ**	**μ**	**LT trend**	**ST trend**
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

New Hatchery Information

FRH currently aims to release 5 million spring-run chinook salmon smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.6). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.7).

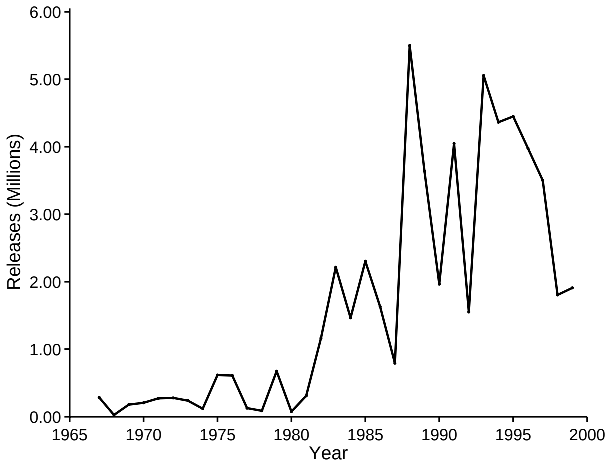

Figure A.2.9.6. Number of spring-run chinook salmon released by Feather River Hatchery.

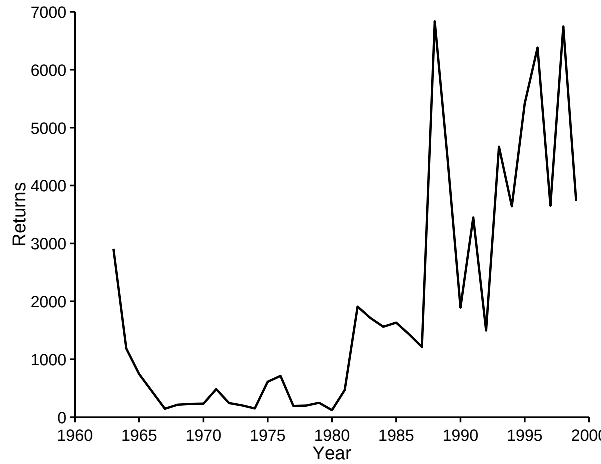

Figure A.2.9.7. Number of spring-run chinook salmon returning to Feather River Hatchery.

New Comments

The State Water Contractors (SWC) submitted several documents, one of them relevant to the status review for CV spring-run chinook salmon. The document, "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," argues that Feather River spring-run chinook salmon should not be included in the CV spring-run chinook salmon ESU and do not otherwise warrant protection under the ESA. SWC also suggested that NMFS conduct a series of evaluations of the following topics:

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation
3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included: 1) an analysis by B.J. Miller showing that significant and expensive changes to water operations in the delta provide fairly modest benefits to chinook salmon populations; 2) "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," discussed in the preceding paragraph; 3) a memo from J.F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

A.2.9.3 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer, and Butte Creek populations noted in the most recent previous status review (NMFS 1999) have apparently continued, probably due in part to the combined effects of habitat restoration, reduced fishing effort in the ocean, and favorable climatic conditions. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring-run chinook salmon are not closely related to the Mill, Deer, and Butte Creek spring-run chinook salmon populations.

A.3 CHINOOK SALMON BRT CONCLUSIONS

Snake River fall-run chinook salmon ESU

A majority (60%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). This represented a somewhat more optimistic assessment of the status of this ESU than was the case at the time of the original status review, when the BRT concluded that Snake River fall-run chinook salmon "face a substantial risk of extinction if present conditions continue" (Waples et al. 1991). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.0 for growth rate/productivity to 3.6 for spatial structure (Table A.3.2).

On the positive side, the number of natural origin spawners in 2001 was well in excess of 1000 for the first time since counts at Lower Granite Dam began in 1975. Management actions have reduced (but not eliminated) the fraction of fish passing Lower Granite Dam that are strays from out-of-ESU hatchery programs. Returns in the last two years also reflect an increasing contribution from supplementation programs based on the native Lyons Ferry Broodstock. With the exception of the increase in 2001, the ESU has fluctuated between approximately 500-1000 adults, suggesting a somewhat higher degree of stability in growth rate and trends than is seen in many other salmon populations.

In spite of the recent increases, however, the recent geometric mean number of naturally produced spawners is still less than 1000, a very low number for an entire ESU. Because of the large fraction of naturally spawning hatchery fish, it is difficult to assess the productivity of the natural population. The relatively high risk matrix scores for spatial structure and diversity (3.5-3.6) reflect the concerns of the BRT that a large fraction of historic habitat for this ESU is inaccessible, diversity associated with those populations has been lost, the single remaining population is vulnerable to variable environmental conditions or catastrophes, and continuing immigration from outside the ESU at levels that are higher than occurred historically. Some BRT members were concerned that the efforts to remove stray, out-of-ESU hatchery fish only occur at Lower Granite Dam, well upstream of the geographic boundary of this ESU. Specific concerns are that natural spawners in lower river areas will be heavily affected by strays from Columbia River hatchery programs, and that this approach effectively removes the natural buffer zone between the Snake River ESU and Columbia River ocean-type chinook salmon. The effects of these factors on ESU viability are not known, as the extent of natural spawning in areas below Lower Granite Dam is not well understood, except in the lower Tucannon River.

Snake River spring/summer-run chinook salmon ESU

About two-thirds (68%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). As indicated by mean risk matrix scores, the BRT had much higher concerns about abundance (3.6) and growth rate/productivity (3.5) than for spatial structure (2.2) and diversity (2.3) (Table A.3.2).

Although there are concerns about loss of an unquantified number of spawning aggregations that historically may have provided connectivity between headwater populations, natural spawning in this ESU still occurs in a wide range of locations and habitat types.

Like many others, this ESU saw a large increase in escapement in many (but not all) populations in 2001. The BRT considered this an encouraging sign, particularly given the record low returns seen in many of these populations in the mid 1990s. However, recent abundance in this ESU is still short of the levels that the proposed recovery plan for Snake River salmon indicated should be met over at least an eight year period (NMFS 1995). The BRT considered it a positive sign that the non-native Rapid River broodstock has been phased out of the Grande Ronde system, but the relatively high level of both production/mitigation and supplementation hatcheries in this ESU leads to ongoing risks to natural populations and makes it difficult to assess trends in natural productivity and growth rate.

Upper Columbia River spring-run chinook salmon ESU

Assessments by the BRT of the overall risks faced by this ESU were divided, with a slight majority (53%) of the votes being cast in the "danger of extinction" category and a substantial minority (45%) in the "likely to be endangered" category (Table A.3.1). The mean risk matrix scores reflect strong ongoing concerns regarding abundance (4.4) and growth rate/productivity (4.5) in this ESU and somewhat less (but still significant) concerns for spatial structure (2.9) and diversity (3.5) (Table A.3.2).

Many populations in this ESU have rebounded somewhat from the critically low levels that immediately preceded the last status review evaluation, and this was reflected in the substantial minority of BRT votes cast that were not cast in the "danger of extinction" category. Although this was considered an encouraging sign by the BRT, the last year or two of higher returns come on the heels of a decade or more of steep declines to all time record low escapements. In addition, this ESU continues to have a very large influence by hatchery production, both from production/mitigation and supplementation programs. The extreme management measures taken in an effort to maintain populations in this ESU during some years in the late 1990s (collecting all adults from major basins at downstream dams) are a strong indication of the ongoing risks to this ESU, although the associated hatchery programs may ultimately play a role in helping to restore self-sustaining natural populations.

Lower Columbia River chinook salmon ESU

A majority (71%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.2 for abundance to 3.9 for diversity (Table A.3.2).

All of the risk factors identified in previous reviews were still considered important by the BRT. The Willamette/Lower Columbia River TRT has estimated that 8-10 historic populations in this ESU have been extirpated, most of them spring-run populations. Near loss of that important life history type remains in important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most populations in this ESU have not seen as pronounced increases in recent years as occurred in many other geographic areas.

Upper Willamette River chinook salmon ESU

A majority (70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements (mean risk matrix scores ranged from 3.1 for growth rate/productivity to 3.6 for spatial structure) (Table A.3.2).

Although the number of adult spring-run chinook salmon crossing Willamette Falls is in the same range (about 20,000–70,000) it has been for the last 50 years, a large fraction of these are hatchery produced. The score for spatial structure reflects concern by the BRT that perhaps a third of the historic habitat used by fish in this ESU is currently inaccessible behind dams, and the BRT remained concerned that natural production in this ESU is restricted to a very few areas. Increases in the last 3-4 years in natural production in the largest remaining population (the McKenzie) were considered encouraging by the BRT. With the relatively large incidence of hatchery fish, it is difficult to determine trends in natural production.

Puget Sound chinook salmon ESU

A majority (74%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 2.9 for spatial structure to 3.6 for growth rate/productivity (Table A.3.2).

Most population indices for this ESU have not changed substantially since the last BRT assessment. The Puget Sound TRT has identified approximately 31 historic populations, of which 9 are believed to be extinct, with most of the populations that have been lost being early run. Other concerns noted by the BRT are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity (and, likely, associated life history types). Although populations in this ESU have not experienced the sharp increases in the last 2-3 years seen in many other ESUs, more populations increased than decreased over the 4 years since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent natural production within the ESU is only a fraction of estimated historic run size. On the positive side, harvest rates for all populations have been reduced from their peaks in the 1980s, and some hatchery reforms have been implemented (e.g., elimination of many net pen programs that were leading to widespread straying, and transition of other programs to more local broodstocks). The BRT felt that these management changes should help facilitate recovery if other limiting factors (especially habitat degradation) are also addressed. The BRT felt that the large recovery effort organized around the Puget Sound Shared Strategy was a positive step because it could help to link and coordinate efforts in many separate, local watersheds.

California Coastal chinook salmon ESU

A majority (67%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with votes falling in the "danger of extinction" category outnumbering those in "not warranted" category by nearly 2-to-1 (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.1 for diversity to 3.9 for abundance (Table A.3.2).

The BRT was concerned by continued evidence of low population sizes relative to historical abundance and mixed trends in the few time series of abundance indices available for analysis, and by the low abundances and potential extirpations of populations in the southern part of the ESU. The BRT's concerns regarding genetic integrity of this ESU were moderate or low relative to similar issues for other ESUs because 1) hatchery production in this ESU is on a minor scale, and 2) current hatchery programs are largely focused on supplementing and restoring local populations. However, the BRT did have concerns with respect to diversity that were based largely on the loss of spring-run chinook salmon in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU. Overall, the BRT was strongly concerned by the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity and distribution of chinook salmon in this ESU.

Sacramento River winter-run chinook salmon ESU

A majority (60%) of the BRT votes fell into the "in danger of extinction" category, with a minority (38%) voting for the "likely to become endangered" and only 2% voting for "not warranted." (Table A.3.1). The main VSP concerns were in the spatial structure and diversity categories (4.8 and 4.2, respectively), although there was significant concern in the abundance and productivity categories (3.7 and 3.5, respectively) (Table A.3.2).

The main concerns of the BRT relate to the lack of diversity within this ESU. The BRT was very troubled by the fact that this ESU is represented by a single population that has been displaced from its historic spawning habitat into an artificial habitat created and maintained by a dam. The BRT presumed that several independent populations of winter-run chinook salmon were merged into a single population, with the potential for a significant loss of life history and genetic diversity. Furthermore, the population has passed through at least two recent bottlenecks—one when Shasta Dam was filled and another in the late 1980s-early 1990s—that probably further reduced genetic diversity. The population has been removed from the environment where it evolved, dimming its long-term prospects for survival. The BRT was modestly heartened by the increase in abundance since the lows of the late 1980s and early 1990s.

Central Valley spring-run chinook salmon ESU

A large majority (69%) of the BRT votes fell into the “likely to become endangered” category, with a minority (27%) of votes going to “in danger of extinction” and 4% “not warranted” (Table A.3.1). There was roughly equal concern about abundance, spatial structure and diversity (3.5-3.8), and less concern about productivity (2.8) (Table A.3.2).

A major concern of the BRT was the loss of diversity caused by the extirpation of spring-run chinook salmon populations from most of the Central Valley, including all San Joaquin tributaries. The only populations left in the Sierra Nevada ecoregion are supported by the Feather River hatchery. Another major concern of the BRT was the small number and location of extant spring-run chinook salmon populations-- only three streams, originating in the southern Cascades, support self-sustaining runs of spring-run chinook salmon, and these three streams are close together, increasing their vulnerability to catastrophe. Two of the three extant populations are fairly small, and all were recently quite small. The BRT was also concerned about the Feather River spring-run chinook salmon hatchery population, which is not in the ESU but does produce fish that potentially could interact with other spring-run chinook salmon populations, especially given the off-site release of the production.

Table A.3.1. Tally of FEMAT vote distribution regarding the status of 9 chinook salmon ESUs reviewed by the chinook salmon BRT. Each of 15 BRT members allocated 10 points among the three status categories.

ESU	At Risk of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River fall-run	38	91	21
Snake River spring/summer-run	30	102	18
Upper Columbia River spring-run	79	67	4
Puget Sound	12	111	27
Lower Columbia River	25	107	18
Upper Willamette River	32	105	13
California Coastal[1]	36	100	13
Sacramento River winter-run[2]	78	49	3
CA Central Valley spring-run[2]	35	90	5

[1] One BRT member assigned 9 points [2] Votes tallied for 13 BRT members

Table A.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 9 chinook salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River fall-run	3.4 (2-5)	3.0 (2-5)	3.6 (2-5)	3.5 (2-5)
Snake River spring/summer-run	3.6 (2-5)	3.5 (3-5)	2.2 (1-3)	2.3 (1-3)
Upper Columbia River spring-run	4.4 (3-5)	4.5 (3-5)	2.9 (2-4)	3.5 (2-5)
Puget Sound	3.3 (2-4)	3.6 (3-4)	2.9 (2-4)	3.2 (2-4)
Lower Columbia River	3.2 (2-4)	3.7 (3-5)	3.5 (3-4)	3.9 (3-5)
Upper Willamette River	3.7 (2-5)	3.1 (2-5)	3.6 (3-4)	3.2 (2-4)
California Coastal[1]	3.9 (3-5)	3.3 (3-4)	3.2 (2-4)	3.1 (2-4)
Sacramento River winter-run[2]	3.7 (3-5)	3.5 (2-5)	4.8 (4-5)	4.2 (3-5)
CA Central Valley spring-run[2]	3.5 (3-4)	2.8 (2-4)	3.8 (3-5)	3.8 (3-5)

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A.5 APPENDICES

Appendix A.5.1. SSHAG (2003) categorizations of hatchery populations of the nine chinook salmon ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

	Stock	Run	Basin	SSHAG Category
Snake River fall-run	Lyons Ferry	Fall	Snake River	2a
Snake River spring/summer-run	McCall (supplementation)	Spring	Salmon	1a
	McCall (production)	Spring	Salmon	2a
	Rapid River	Spring	Little Salmon	3c
	Sawtooth	Spring	Salmon	1a
	Pahsimeroi	Summer	Salmon	1a and 2a
	Captive Broodstock			
	Catherine Creek	Summer	Grande Ronde	1a
	Upper Grande Ronde	Summer	Grande Ronde	1a
	Lostine River	Summer	Grande Ronde	1a
	Clearwater	Spring	Clearwater	2b
	Imnaha (# 29)	Spr/Sum	Imnaha	1a
	Dworshak	Spring	Clearwater	3b or 4
	Kooskia	Spring	Clearwater	3b or 4
	Tucannon	Spring	Tucannon	1a
Upper Columbia River spring-run	Leavenworth NFH	Spring	Wenatchee	3c or 4
	Entiat NFH	Spring	Entiat	3c, 4, or 2b
	Winthrop NFH	Spring	Methow	3c or 4
	Chiwawa	Spring	Wenatchee	1a
	Methow Composite	Spring	Methow	2a/c
	Twisp	Spring	Methow	1a
	Chewuch	Spring	Methow	1a
	Methow	Spring	Methow	3c or 4
	U. Columbia River Captive			
	Nason	Spring	Wenatchee	1a
	White River	Spring	Wenatchee	1a

Appendix A.5.1 (cont.)				
	Twisp	Spring	Methow	1a
	Methow	Spring	Methow	1a
	Ringold Hatchery	Spring	U. Col. River	3c or 4
	Carson Hatchery	Spring	Wind	3c or 4
Puget Sound	Kendall Creek	Spring	Nooksack	2a
	Lummi Bay	Fall	Nooksack	3b or 3c
	Samish River	Fall	Samish	3b
	Marblemount	Spring	Skagit	2c
	Marblemount	Summer	Skagit	1a
	Marblemount	Fall	Skagit	1a
	Tulalip	Spring	Tulalip Bay	3b or 3c
	Tulalip	Summer	Tulalip Bay	2b or 2c
	Tulalip	Fall	Tulalip Bay	3b or 3c
	N. Fork Stillaguamish	Summer	Stillaguamish	1a
	Wallace River	Summer	Snohomish	2a
	Issaquah Hatchery	Fall	Lake Washington	2b
	UW Portage Bay	Fall	Lake Washington	3b or 4
	Soos Creek	Fall	Green	2a
	Keta Creek	Fall	Green	2a
	Grover's Creek	Fall	East Kitsap	2b
	Garrison Springs	Fall	Chambers Creek	2b
	Voights Creek	Fall	Puyallup	2b or 2c
	Diru Creek	Fall	Puyallup	2b or 2c
	White River	Spring	Puyallup	2a
	Clear/Kalama Creeks	Fall	Nisqually	2a or 2b
	Minter Creek	Fall	S. Sound	2b
	Tumwater Falls	Fall	Deschutes	2b
	George Adams	Fall	Skokomish	2b or 3c
	WSC Hood Canal	Fall	Skokomish	2b or 3c
	Finch Creek	Fall	S. Hood Canal	2b or 3c
	Hamma Hamma	Fall	S. Hood Canal	2b or 3c
	Big Beef Creek	Fall	N. Hood Canal	2b

Appendix A.5.1 (cont.)				
	Dungeness	Spring	Dungeness	1a
	Elwha	Fall	Elwha	2a
	Glenwood Springs	Fall	San Juan Islands	2b
Lower Columbia River	Sea Resources	Fall	Chinook River	2b
	Abernathy NFH	Fall	Abernathy Creek	2b
	Grays River	Fall	Grays	2b
	Elochoman	Fall	Elochoman	2b
	Cowlitz	Fall	Cowlitz	2a
	Cowlitz	Spring	Cowlitz	2a
	Toutle	Spring	Cowlitz	2c
	Kalama	Fall	Kalama	2a
	Kalama	Spring	Kalama	2b
	Lewis	Spring	Lewis	2a or 2b
	Washougal	Fall	Washougal	2a or 2b
	Carson	Spring	Wind	4
	LWS NFH	Fall	Little White	4
	Spring Creek NFH	Fall	Spring Creek	2a
	Klickitat	Fall	Klickitat	4
	Willamette	Spring	Youngs Bay	4
	Big Creek	Fall	Big Creek	3b
	Rogue River (#52)	Fall	Youngs Bay	4
	Klaskanine (# 15)	Fall	Klaskanine	2b
	Willamette	Spring	Klaskanine	4
	Bonneville (#14)	Fall	Gorge	3a
	Bonneville (#95)	Fall	Gorge	4
	Hood River	Spring	Hood	4
Upper Willamette River	N. Fork Santiam (#21)	Spring	Santiam	2a and 2b
	Willamette Hatchery (#22)	Spring	M. Fork Willamette	2b or 2c
	McKenzie (#24)	Spring	McKenzie	2a
	S. Fork Santiam (#23)	Spring	Santiam	2b
	Clackamas (# 19)	Spring	Clackamas	2b or 2c

Appendix A.5.1 (cont.)				
California Coastal	Mad River	Fall	Mad River	2q,b,c
	Freshwater Creek	Fall	Humboldt Bay	1a
	Yaeger Creek	Fall	Van Duzen	1a
	Redwood Creek	Fall	Redwood Creek	1a
	Hollow Tree Creek	Fall	Eel River	1a
	Van Arsdale	Fall	Eel River	2a
	Mattole	Fall	Mattole River	1a
Sacramento River winter-run	Livingston Stone	Winter	Sacramento River	1a
California Central Valley spring-run	Feather River	Spring	Feather River	4 or 2b

Appendix A.5.2. Chinook Salmon Time Series Data Sources

Snake River Fall Chinook Salmon ESU

Population	Snake River fall-run
Years of Data, Length of Series	1975 - 2001, 27 years
Abundance Type	Dam count
Abundance Notes / References	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Hatchery Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Harvest Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Age Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)

Snake River Spring/Summer Chinook ESU

Population	Snake River spring-run total
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Dam Count
Abundance Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Hatchery Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Average from Beamesderfer et al. 1998

Population	Snake River summer-run total
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Dam Count
Abundance Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Hatchery Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Yearly data from Beamesderfer et al. 1998, recent years updated with an average

Population	Alturas Lake Creek
Years of Data, Length of Series	1957 - 2001, 45 years

Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Myers et al. 1998 (org. citation is Keifer et al. 1992), used Salmon River age structure

Population	Bear Valley / Elk Creek
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Expanded Redd Count
Abundance Notes / Reference	Beamesderfer et al 1998, IDFG updated redd counts
Hatchery Notes / Reference	Beamesderfer et al 1998
Harvest Notes / Reference	CTC db from Tom G.
Age Notes / Reference	IDFG, used MF composite to fill in missing years

Population	Big Creek summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet 2000, Brown 2002 (1998-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	MF Composite Age Data

Population	Big Sheep Creek
Years of Data, Length of Series	1957 - 2001, 39 years
Abundance Type	Redd Count
Abundance Notes / Reference	Abundance database reference #52 (all years prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998

Population	Camas Creek
Years of Data, Length of Series	1972 - 2001, 29 years
Abundance Type	Redd Count
Abundance Notes / Reference	1998-2001 redd counts: 2002 IDFG comment letter
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)

Age Notes / Reference	Middle Fork composite age data
Population	Catherine Cr (Index Area)
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Abundance database reference #52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Chamberlain Creek
Years of Data, Length of Series	1952 - 1997, 22 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41052
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	Keifer et al. 1992 (in Myers et al. 1998), used Middle Fork Salmon River age structure
Population	Grande Ronde River, Upper (Index area)
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Redd count
Abundance Notes / Reference	Streamnet (prior to 1997); Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	R. Carmichael, ODFW. 1/2003
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Herd Creek
Years of Data, Length of Series	1958 - 1986, 28 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41018
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Used Valley Creek spring chinook age structure
Population	Imnaha River
Years of Data, Length of Series	1953 - 2001, 49 years
Abundance Type	Expanded redd count

Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Beamesderfer et al. 1998
Harvest Notes / Reference	R. Carmichael, ODFW. 1/2003
Age Notes / Reference	Beamesderfer et al. 1998

Population	Johnson Creek
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Expanded redd count
Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Beamesderfer et al. 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used South Fork aggregate data to fill in missing years

Population	Lake Creek summer-run
Years of Data, Length of Series	1952 - 2000, 49 years
Abundance Type	Redds per Mile
Abundance Notes / Reference	Streamnet: 41059
Hatchery Notes / Reference	R.A.A.C. run reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. run reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used South Fork Salmon aggregate data to fill in missing years

Population	Lemhi River
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used a weigted average to fill in missing years

Population	Lick Creek (Imnaha)
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Redd count
Abundance Notes / Reference	Adundance database reference #52 (prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998

Population	Lookingglass Creek
Years of Data, Length of Series	1957 - 2001, 44 years
Abundance Type	Redd count
Abundance Notes / Reference	Streamnet 2000 (prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years

Population	Loon Creek
Years of Data, Length of Series	1957 - 2001, 43
Abundance Type	Redd count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Middle Fork Salmon River composite age structure data

Population	Lostine River (Index Area)
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Redd Count
Abundance Notes / Reference	Adundance database reference #52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al 1998, recent years updated with U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years

Population	Marsh Creek
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total Live Count
Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used Middle Fork Salmon River composite to fill in missing years

Population	Minam River
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Total live count

Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Pahsimeroi River
Years of Data, Length of Series	1980 - 2001, 22 years
Abundance Type	Total live count
Abundance Notes / Reference	Streamnet 2002 (1980-2000), Rogers 2002 (2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Used Lemhi River age structure
Population	Poverty Flat
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total Live Count
Abundance Notes / Reference	Beamesderfer et al 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used South Fork Salmon River aggregate to fill in missing years
Population	Rapid River (L. Salmon)
Years of Data, Length of Series	1972 - 2001, 30 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet 2002 (1972-2000), Rogers 2002 (2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	
Population	Salmon River, East Fork summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41016
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat summer-run

Population	Salmon River, South Fork summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG

Population	Salmon R, North Fork spring-run
Years of Data, Length of Series	1960 - 2000, 27 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet, Brown 2002 (1996-2000)
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	

Population	Salmon River, Upper spring-run
Years of Data, Length of Series	1954 - 2001, 48 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG

Population	Salmon River, Upper summer-run
Years of Data, Length of Series	1957 - 1997, 40 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41002
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat age structure

Population	Secesh River summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd count

Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used South Fork Salmon aggregate to fill in missing years

Population	Snake River spring-run
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Total live count
Abundance Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Hatchery Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Harvest Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Age Notes / Reference	Beamesderfer at al. 1998

Population	Snake River summer-run
Years of Data, Length of Series	1979 - 2002, 24 years
Abundance Type	Dam count
Abundance Notes / Reference	CTC Report 2002
Hatchery Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Harvest Notes / Reference	CTC Report 2002
Age Notes / Reference	Beamesderfer at al. 1998

Population	Sulphur Cr
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total live count
Abundance Notes / Reference	IDFG comments to NMFS, 2002
Hatchery Notes / Reference	Beamesderfer at al. 1998
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used Middle Fork Salmon River composite to fill in missing years

Population	Tucannon River
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Total live count

Abundance Notes / Reference	WDFW comments to NMFS, 2003.
Hatchery Notes / Reference	WDFW comments to NMFS, 2003.
Harvest Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Age Notes / Reference	1985-99 average and 2000 estimate of spring chinook age composition from WDFW Rep. Gallinat, J. P., J. Bumgarner, L. Ross and M. Varney. 2001. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program. 2000 annual rept. FPA01-05. 44p.

Population	Valley Creek, Upper spring-run
Years of Data, Length of Series	1957 - 2001, 44 years
Abundance Type	Redd count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used Salmon River aggregate to fill in missing years

Population	Valley Creek, Upper summer-run
Years of Data, Length of Series	1952 - 1997, 49 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41009
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	

Population	Wallowa River
Years of Data, Length of Series	1963 - 2001, 39 years
Abundance Type	Redd count
Abundance Notes / Reference	52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	R. Carmichael, ODFW. 1/2003
Harvest Notes / Reference	Beamesderfer et al 1998, recent years updated with U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998, used Grande Ronde age structure

Population	Wenaha River (Index Area)
Years of Data, Length of Series	1963 - 2001, 39 years
Abundance Type	Redd Count

Abundance Notes / Reference	52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC (used South Fork Wenaha values)
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Used pooled Grande Ronde River age structure values (Beamesderfer)

Population	Yankee Fork River summer-run
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet (SN ref: Elms-Cockrum 1994-1997), Brown 2002 (1998-2001)
Hatchery Notes / Reference	No annual sampling; assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat age structure

Population	Yankee Fork, West Fork spring-run
Years of Data, Length of Series	1960 - 2001, 41 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet, Brown 2002 (1998-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Keifer et al. 1992 (in Myers et al. 1998), used Salmon River age structure

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Population	South Fork Nooksack River
Years of Data, Length of Series	1984-2001
Abundance Type	Carcass/redd
Abundance References	Pete Castle & Ned Currens, personal communication (2001a); Nooksack co-manager meeting (NMFS and Co-managers 2002)
Abundance Notes	Escapements are an expansion of carcass spawning surveys in the upper south fork and in Huchinson and Skookum creeks prior to 1999 and redd counts times 2.5 from 1999 on. They are designated early spawners; counts stop 1 October (fish after that thought to be out of basin strays)
Hatchery Reference	Pete Castle & Ned Currens (2001a); Nooksack co-manager meeting (NMFS and co-managers 2002)
Hatchery Notes	Contribution rate of hatchery fish to natural spawning only estimated since 1999 (carcass surveys

	looking for marked fish). It is assumed that the number of hatchery fish on spawning grounds is correlated with number of hatchery fish returning rather than number of fish on spawning grounds. Therefore, the stray rate of hatchery to spawning grounds for years without data is estimated as the average of the three years observed, not to exceed 43% of the spawning fish
Harvest Reference	CTC Model and ER analyses output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates from CTC model run for Nooksack stock.
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=226 fish sampled from 1993-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Cedar River
Years of Data, Length of Series	1965-2002
Abundance Type	Live count surveys
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Escapement estimates are from live count surveys and expanded by area under the curve method
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=9 fish sampled in 1988. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dosewallips River
Years of Data, Length of Series	1987-2002
Abundance Type	Live/dead surveys and redd counts
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Three years reported no escapement; the TRT is using 1 fish each for those years (the surveyors could easily have missed one fish and it makes calculations easier)
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Hatchery Notes	Probably few if any hatchery strays into the Dosewallips.
Harvest Reference	1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	n=9 fish sampled from 1995-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dungeness River
Years of Data, Length of Series	1986-2002
Abundance Type	
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Escapements for Dungeness are for spring/summer stock with spawning from August to mid-Oct
Hatchery Reference	Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF et. al 1992)
Hatchery Notes	There are no estimates of contribution rate of hatchery fish to natural spawners?
Harvest Reference	
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis

	may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=99 fish sampled from 1987-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Elwha River
Years of Data, Length of Series	1986-2002
Abundance Type	
Abundance References	2001 Management Framework Plan and Salmon Runs' Status for the Strait of Juan de Fuca (WDFW et al 2001c); NMFS/Co-managers Meeting Point No Point (NMFS and Co-managers 2002)
Abundance Notes	Escapement to natural grounds equals total post fishery escapement minus broodstock take and rack return, and includes pre-spawning mortality
Hatchery Reference	2001 Management Framework Plan and Salmon Runs' Status for the Strait of Juan de Fuca (WDFW et al 2001c); NMFS/Co-managers Meeting Point No Point (NMFS and Co-managers 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=2322 fish sampled from 1989-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Green River
Years of Data, Length of Series	1968-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Estimation of

	contribution of hatchery origin fall-run chinook salmon to Duwamish-Green River spawning ground populations (NWIFC 2001)
Abundance Notes	Escapements for this population do not include spawning in Newaukum Creek. Escapement estimates are based on redd counts in specified sections of the river and expanded by a factor to reflect the total spawning habitat of the river.
Hatchery Reference	Estimation of contribution of hatchery origin fall-run chinook salmon to Duwamish-Green River spawning ground populations (NWIFC 2001)
Hatchery Notes	Hatchery contribution estimates from Soos, Icy, and Keta creeks hatcheries
Harvest Reference	CTC Model and ER analyses output (CTC 2000)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=2454 fish sampled from 1988-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Lower Sauk River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data. (Hayman 2002)
Abundance Notes	
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries

	and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling from Upper Skagit; n=1362 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Lower Skagit River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Abundance Notes	
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Hatchery Notes	Marblemount Hatchery rack returns.
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=440 fish sampled from 1992-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Nisqually River
Years of Data, Length of Series	1968-2002
Abundance Type	Carcass

Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers.comm. (Scott 2002)
Abundance Notes	Escapements are an expansion of spawning surveys in Prairie River/creek.
Hatchery Reference	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	No estimates of contribution of hatchery fish to natural spawning have been made in past, but will start in 2002
Harvest Reference	CTC ER and chinook model output (CTC 1999); Review of 2000 Ocean Salmon Fisheries (PFMC 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling from Upper Skagit; n=1362 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	North Fork Nooksack River
Years of Data, Length of Series	1984-2001
Abundance Type	Carcass
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002); Pete Castle and Ned Currens pers comm, memo "North Fork Nooksack native spring chinook escapement methodology" (Castle and Currens 2001a,b)
Abundance Notes	Total chinook on the spawning grounds = expanded carcass counts on spawning grounds plus turnback hatchery fish.
Hatchery Reference	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002); Pete Castle and Ned Currens pers comm, memo "North Fork Nooksack native spring chinook escapement methodology" (Castle and Currens 2001a,b)

Hatchery Notes	Contribution rate of cultured fish (hatchery and acclimation releases) to natural spawning started in 1988 with significant returns from the hatchery program.
Harvest Reference	CTC model and ER analyses output (CTC 2000) 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=359 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands).

Population	Lake Washington tributaries
Years of Data, Length of Series	1983-2002
Abundance Type	Live counts
Abundance References	SaSI database (Campbell 2000); NMFS/Co-manager meeting on abundance and productivity data (NMFS and Co-managers 2002)
Abundance Notes	Escapement estimates are from live counts expanded for area under the curve.
Hatchery Reference	SaSI database (Campbell 2000); NMFS/Co-manager meeting on abundance and productivity data (NMFS and Co-managers 2002)
Hatchery Notes	No estimate of contribution rate of hatchery fish to spawning. There are trapping data that indicate the presence of hatchery strays.
Harvest Reference	CTC model and ER analyses output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=82 fish sampled in 1985 and 1988. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years

	(Norma Sands).

Population	North Fork Stillaguamish River
Years of Data, Length of Series	1974-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Escapement estimates are from foot and boat surveys of the mainstem and foot surveys of the tributaries of redd counts.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	Stillaguamish Tribal Harvey Creek Hatchery, supplementation program, does not have rack returns. Return to hatchery is actual brood stock take which occurs in the North Fork. Hatchery supplementation program began in early 1980s. Returns started in 1986
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Otolith project; n=2840 fish sampled from 1987 and 1988-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Puyallup River
Years of Data, Length of Series	1968-2002
Abundance Type	Redd and live/dead fish count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); 1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); Jim Scott, pers comm (Scott 2002)

Abundance Notes	Index counts of spawning from South Prairie Creek, which in the past were from a limited area and not a good index of the system. Surveys now are from the entire S. Prairie Creek basin. These started in 1992 by float and foot surveys of redds and live/dead fish. However, estimates given here are based on index count only through 1998. Revisions are being made back to 1992 and should be available soon.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); 1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC ER and chinook model output for fishing rates and new runs with fingerling releases (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=930 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Skokomish River
Years of Data, Length of Series	1987-2002
Abundance Type	Various
Abundance References	Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF 1993); NMFS/comanager meeting, Point No Point (NMFS and Comanagers 2002)
Abundance Notes	Escapements are from the Comanagers management report. Estimates should be available from 1976 although there is concern about data prior to 1990 (T. Johnson) (see NWIFC website). This population includes index survey sites in both main river including NF and several tributaries; mainly foot, sometimes float. Escapement estimates vary from year to year in survey type and expansion (from 1990 on no expansion for unsurvey areas - in other words all spawning areas are

	surveyed). Quality of escapement data considered good (SASSI document)
Hatchery Reference	Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF 1993); NMFS/comanager meeting, Point No Point (NMFS and Comanagers 2002)
Hatchery Notes	Hatchery strays from the George Adams H, HoodCanal (Hoodsport H, and Enetai H) are found on the spawning grounds, but there is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1 fish sampled in 2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Skykomish River
Years of Data, Length of Series	1965-2002
Abundance Type	Aerial surveys, redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Abundance Notes	Escapements for the Skykomish population have been updated from the comanagers (Curt Kraemer & Kit Rawson 1/9/02) for 1979-2001. The Skykomish population includes 10 survey sites in the Skykomish, Wallace, Bridal Veil, Sunset Falls, Pilchuck, and Sultan rivers. Escapement estimates are from aerial surveys of the mainstem and foot surveys of the tributaries (redd counts). Escapement estimates for the total Snohomish system are available from 1965. Skykomish estimates for 1965-1978 are made by subtracting Skykomish population escapements from the total system escapements
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)

Hatchery Notes	From 1997 to the present, contribution rate of hatchery fish to natural spawning is estimated by sampling spawning grounds for otolith marked hatchery fish from Tulalip and Wallace Hatcheries. Prior to 1997, the hatchery contribution is estimated from "run reconstruction" of hatchery returns (Kit Rawson 11/19/01).
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); Terminal Harvest Rates for Snohomish R. Using Terminal Run Reconstruction (Rawson 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001); Age database (WDFW et al 2001a)
Age Notes	Scale or otolith sampling; n=561 fish sampled from 1989-1999, except years 1990 and 1994. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands).

Population	Snoqualmie River
Years of Data, Length of Series	1965-2002
Abundance Type	From hatchery straying estimates and otolith sampling
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Abundance Notes	Escapements for the Snoqualmie population have been updated from the comanagers (Curt Kraemer & Kit Rawson 11/19/01 7 1/9/02) for 1979-2000. The Snoqualmie population includes 6 survey sites in the Snoqualmie River and tributaries of the Snoqualmie R. Escapement for the SaSSI Snohomish fall-run stock are available from 1965 (Jim Scott spreadsheet) and, on average, the Snoqualmie portion represented 62% of the Snohomish fall-run escapement. Thus, estimates of Snoqualmie escapement prior to 1979 are estimated as 62% of the Snohomish fall-run escapement.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan:

	Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Hatchery Notes	From 1997 to the present, contribution rate of hatchery fish to natural spawning is estimated by sampling spawning grounds for otolith marked hatchery fish from Tulalip and Wallace Hatcheries. Prior to 1997, the hatchery contribution is estimated from "run reconstruction" of hatchery returns (Kit Rawson 11/19/01).
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); Terminal Harvest Rates for Snohomish R. Using Terminal Run Reconstruction (Rawson 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001); Age database (WDFW et al 2001a)
Age Notes	Scale sampling and scale/otolith sampling; n=572 fish sampled from 1989 and 1992-1999. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	South Fork Stillaguamish River
Years of Data, Length of Series	1974-2002
Abundance Type	redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm. (Scott 2002)
Abundance Notes	Escapement estimates are from foot and boat surveys of the mainstem and foot surveys of the tributaries of redd counts
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm. (Scott 2002)
Hatchery Notes	It is assumed that no hatchery fish stray to the spawning grounds of the South Fork Stillaguamish

Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Otholith project; n=1641 fish sampled from 1987 and 1989-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Suiattle River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count; peak live/dead counts
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Before 1994 esc method was peak live/dead counts for partial spawning grounds to get fish per mile and then expand for total spawning grounds (by 8.5). 1994 and after use redd counts cover entire spawning area
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	No hatchery in basin; broodstock take from the Suiattle 1974-1988 to the Marblemount Hatchery (and fry released at Hatchery)
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source

Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=672 fish sampled from 1986-1990 and 1992-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Upper Cascade River
Years of Data, Length of Series	1984-2002
Abundance Type	Live/dead counts expanded for area/redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002); NMFS/Comanagers meeting (NMFS and Comanagers 2002)
Abundance Notes	Before 1992 esc method was peak live/dead counts with expansion for uncovered ground. 1992 and after use redd counts cover entire spawning area
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002); NMFS/Comanagers meeting (NMFS and Comanagers 2002)
Hatchery Notes	The hatchery is at the mouth of the Cascade, but releases fish into the Suiattle.
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=157 fish sampled from 1992-1998 and 2000-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	Upper Sauk River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count; peak live/dead
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Before 1994 escapement estimation method was peak live/dead counts with expansion for uncovered ground. 1994 and after use redd counts and cover entire spawning area
Hatchery Reference	
Hatchery Notes	No hatchery in Upper Sauk. Assume the hatchery releases from the Marblemount Hatchery do not influence the Sauk populations
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=349 fish sampled from 1986, 1992-1995, 1997-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	Upper Skagit River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Escapements are based on redd counts and are considered a good measure of relative abundance from year to year
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan:

	Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	Marblemount Hatchery rack returns. The Marblemount Hatchery is situated at the mouth of the Cascade River, such that returns pass through the Lower and Upper Skagit River
Harvest Reference	CTC model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1731 fish sampled from 1992-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	White River
Years of Data, Length of Series	1970-2002
Abundance Type	Trap
Abundance References	1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); SaSI database (Campbell 2000); Chris Phinney, pers comm (Phinney 2001); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Chinook counts from 1970-present are from Buckley trap for the entire season (year round). Does not include any spawning the occurs below the dam which may represent abut 25% of total spawning (11/21/02). Glacial system, thus spawning ground surveys difficult. Starting this year rejecting (not passing upstream) tagged or marked fish (except acclimated fish). Earlier years may include fall-run hatchery fish.
Hatchery Reference	
Hatchery Notes	There is a program to put acclimated hatchery fish on the spawning grounds, will begin to estimate this. No estimates of hatchery contribution prior to 2001. Assume no contribution of hatchery fish to natural spawning
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook

	Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1335 fish sampled from 1990, 1993-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Lower Columbia River chinook salmon ESU

Population	Big White Salmon River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-2000 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Spring Creek
Harvest Reference	Pacific Salmon Commission 2002
Harvest Notes	Estimated exploitation rate on hatchery stocks applied to natural stocks.
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.

Population	Clackamas River fall-run
Years of Data, Length of Series	1967 - 2001, 35 years
Abundance Type	Peak Count
Abundance References	ODFW 1998.

Hatchery Reference	No Hatchery Data
Hatchery Notes	No Hatchery Data
Harvest Reference	No Harvest Data Available
Age Reference	Myers, et al.1998.
Age Notes	Generic fall-run age structure
Population	Coweeman River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates extrapolated from peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	Harvest data based on PFMC models provided by Dell Simmons.
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000
Population	East Fork Lewis River fall-run
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Harvest Reference Stock	Lewis Wild
Harvest Reference	Rawding, Dan (WDFW). 2001a.
Harvest Notes	AEQ ER for Lewis River from Dell Simmons
Age Reference	Rawding, Dan (WDFW). 2001a.

Age Notes	Age distribution for 1980-1983 based on an average of 1984-2000
Population	Lewis River (Brights) fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a. Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Lewis Wild
Harvest Reference	Pacific Salmon Commission. 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000
Population	Middle Gorge Tributaries fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-2000 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000. Age distribution data missing for 1993
Population	Mill Creek fall-run

Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission. 2002
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.

Population	Sandy River fall-run
Years of Data, Length of Series	1988 - 2001, 14 years
Abundance Type	Total from redd count
Abundance References	ODFW 1998
Abundance Notes	The estimate of spawning abundance is based on a one time peak count of live fish on the Sandy River. The index area is 10 miles from the mouth of Gordon Cr. To Lewis & Clark ramp. The number of fish is then multiplied by 2.5 to get the estimate (Streamnet ref # 50070). Fish counts are provided in Streamnet trend # 57517. Surveys were not conducted prior to 1988
Hatchery Reference	ODFW 1998.
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners
Harvest Reference	No Harvest Data Available
Age Reference	Myers et al. 1998.
Age Notes	Generic fall-run age structure

Population	Sandy River late fall-run
Years of Data, Length of Series	1984 - 2001, 18 years
Abundance Type	Total from redd count
Abundance References	ODFW 2002; ODFW 1990; Murtagh, T.; Massey, J.; Bennett, D.E. 1997.
Hatchery Reference	ODFW 1998
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners

Harvest Reference	No Harvest Data Available.
Age Reference	Myers et al.1998.
Age Notes	Generic fall-run age structure
Population	Washougal River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Cowlitz Hatchery
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Kalama River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Lewis River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years

Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.

Population	Upper Cowlitz River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	Myers, et al. 1998.

Population	Youngs Bay fall-run
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish/Mile
Abundance References	Fulop 2002, 2003

Population	Big Creek fall-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile
Abundance References	Fulop 2003

Population	Clatskanie River fall-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile

Abundance References	Fulop 2003

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Population	Clackamas River spring-run
Years of Data, Length of Series	1958 - 2002, 45 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002e.
Abundance Notes	Data are dam counts for NF Dam; adults only, production is mixed
Hatchery Reference	Cramer, Doug. 2002e.
Hatchery Notes	Counts of hatchery vs wild done only for 2001-2002 (Doug Cramer). Doug Cramner estimates the number of marked hatchery fish to be 50%.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle. 2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to Clackamas R Spring-run Chinook.

Population	Mckenzie River spring-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Dam/weir count
Abundance References	Kostow, Kathryn (ODFW). 2002b.
Abundance Notes	Data come from dam counts at Leaburg Dam. Spawning also occurs below the dam.
Hatchery Reference	Kostow, Kathryn (ODFW). 2002b.
Hatchery Notes	Hatchery fish have only been 100% marked in recent years. The hatchery marks are no6t 100% detectable at the dam because a portion of the hatchery fish is double index marked to evaluate the fishery impact to wild fish. Double index markes mean that the hatchery fish has a coded wire tag but it is not externally marked (that is, no fin clip). Therefore, the fish "looks wild" both to the fisherman (who must release the fish) and in the raw dam count. The McKenzie fish managers therefore do several expansions to deal with these issues.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle. 2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to McKenzie R

	Spring-run Chinook.
Population	Sandy River spring-run
Years of Data, Length of Series	1977 - 2001, 25 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002d.
Abundance Notes	Abundance estimates only
Hatchery Reference	No Hatchery Data.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Willamette Falls fall-run
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Howell, P.J.. 1986; Bennett, D.E.. 1986; Bennett, D.E. and C.A. Foster. 1990; Bennett, D.E. and Foster, C.A.. 1994; Bennett, D.E. and C.A. Foster. 1995; Foster, C.A. 1998.
Abundance Notes	2 additional references: Foster 2000 and Foster 2002. Data are for adults and jacks.
Population	Willamette Falls spring-run
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Anonymous. 1998; Foster, C.A. 1998; Foster, C.A. 2000.
Abundance Notes	Data are for adults and jacks.

Appendix A.5.3. Lower Columbia River hatchery release**s.**

Lower Columbia River fall-run chinook salmon (Washington)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Chinook River	1990-1994	Sea Resources	Chinook River	Chinook River	2,598,400
	1990	Sea Resources	Washougal	Chinook River	629,500
	1997-2000	Sea Resources	Chinook River	Chinook River	820,627
	1993	Lower Columbia	Kalama Falls	Deep River	49,400
Grays River	1990-1994	Grays River	Grays River	Grays River	2,767,900
	1991, 1993	Grays River	Kalama Falls	Grays River	1,332,380
	1992	Grays River	Spring Creek	Grays River	1,107,000
	1995-1997	Grays River	Kalama	Grays River	764,550
	1996, 1997	Grays River	Washougal	Grays River	1,745,500
Elochomin River	1990-1994	Elokomin	Elochomin	Elochomin River	17,809,719
	1991	Elokomin	Kalama Falls	Elochomin River	1,046,700
	1995	Beaver Creek	Abernathy	Beaver Creek	377,252
	1997	Beaver Creek	Big Creek	Beaver Creek	1,096,198
	1996-1999	Beaver Creek	Elochoman	Elochoman River	2,081,670
	1995	Beaver Creek	Kalama	Beaver Creek	760,039
	1995-2001	Elochoman	Elochoman	Elochoman River	15,280,038
	1999	Elochoman	Grays River	Elochoman River	174,500
	1997-1998	Elochoman	Washougal	Elochoman River	1,633,200
Lower Columbia River	1996-1998	Cathlamet Ffa	Washougal	Columbia River	1,132,500
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	28,757,600
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	42,322,920
Toutle River	1990-1993	Toutle	Kalama Falls	Green River	5,718,000
	1991-1993	Toutle	Toutle	Green River	2,941,000
	1994	Toutle	Tule	Green River	2,044,500
	1990-1993	Toutle	Washougal	Green River	2,693,400
	2000	North Toutle	Elochoman	Green River	618,266
	1996	North Toutle	Kalama	Green River	1,588,937
	1996-2001	North Toutle	Toutle	Green River	10,584,543
	1996	North Toutle	Washougal	Green River	633,414
Kalama River	1991-1994	Lower Kalama	Kalama	Kalama River	10,701,203
	1990-1994	Kalama Falls	Kalama Falls	Kalama River	17,600,800

	1996-2001	Fallert Cr	Kalama	Fallert Creek	13,998,602
	1995-2001	Kalama Falls	Kalama	Kalama River	20,198,653
Washougal River	1994	Washougal	Kalama Falls	Washougal River	2,443,100
	1992	Washougal	Spring Creek	Washougal River	1,409,300
	1991-1994	Washougal	Washougal	Washougal River	27,002,103
	2000	Washougal	Elochoman	Washougal River	1,312,680
	1995-2001	Washougal	Washougal	Washougal River	32,878,694
Spring Creek	1992	Ringold	L White Salmon	Spring Creek	82,511

Lower Columbia River fall-run chinook salmon (Oregon)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
	1991-1995	Astoria H.S.	Big Creek	Youngs Bay	15,500
	1991-1994	Cedc	Rogue River	Youngs Bay	394,382
	1991, 1992	Step	Big Creek	Youngs Bay	13,758
	1992, 1993	Step	Klaskanine	Youngs Bay	15,700
	1996-1998	Step	Big Creek	Youngs Bay	63,050
	1997, 1998	Step	Unknown	Youngs Bay	16,500
	1995-2002	Youngs Bay	Rogue River	Youngs Bay	4,248,147
	1996-1998	Youngs Bay	Urb	Youngs Bay	828,884
Lower Columbia River	1991	Step	Unknown	Lower Columbia River	25,000
	1996, 1997	Tongue Pt	Rogue River	Tongue Point	54,274
	1996, 1997	Tongue Pt	Urb	Tongue Point	299,715
	1995-1997	Blind Slough	Rogue River	Blind Slough	54,793
Skipanon River	1992-1993	Step	Klaskanine	Skipanon River	3,550
	1996-1999	Step	Big Creek	Skipanon River	15,193
Plympton Creek	1991	Big Creek	Big Creek	Plympton Creek	50,278
Big Creek	1991-1994	Big Creek	Big Creek	Big Creek	34,675,446
	1991-1994	Big Creek	Rogue River	Big Creek	2,798,710
	1993	Big Creek	Kalama Falls	Big Creek	886,471
	1995-2002	Big Creek	Big Creek	Big Creek	40,633,091
	1995-1996	Big Creek	Rogue River	Big Creek	1,530,550
Klaskanine River	1995	Cedc	Rogue River	Klaskanine River	15,758
	1996-1999	Klaskanine	Rogue River	Klaskanine River	3,694,245
Wahkeena Pond	1991-1993	Bonneville	Urb	Columbia River	1,183,764
Johnson Creek	1994, 1995	Step	Tanner Creek	Johnson Creek	99,008

Tanner Creek	1991	Bonneville	Big Creek	Tanner Creek	2,580,763
	1991-1994	Bonneville	Tanner Creek	Tanner Creek	32,862,338
	1991	Bonneville	Wa Tule	Tanner Creek	1,534,122
	1991-1994	Bonneville	Urb	Tanner Creek	26,877,822
	1993	Bonneville	Kalama Falls	Tanner Creek	1,505,421
	1995-1996	Bonneville	Tanner Creek	Tanner Creek	15,369,642
	1995-1996	Bonneville	Wa Tule	Tanner Creek	10,922,745
	1995-2002	Bonneville	Urb	Tanner Creek	43,729,497
	2000-2001	Bonneville	Wa Urb	Tanner Creek	328,426

Lower Columbia River spring-run chinook salmon (Washington)					
rshed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Deep River	1999-2001	Deep River	Cowlitz	Deep Creek	255,657
Abernathy Creek	1991-1996	Abernathy NFH	Abernathy Creek	Abernathy Creek	6,853,504
	1997-1999	Abernathy NFH	Abernathy Creek	Abernathy Creek	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz River	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton River	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz River	53,800
Toutle River	1991, 1993	Toutle	Cowlitz	Green River	641,382
	1995	North Toutle	Toutle	Green River	1,412,100
	1995	North Toutle	Washougal	Green River	1,086,100
	1995-2001	North Toutle	Cowlitz	Green River	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis River	1,229,262
	1994	Lewis River	Kalama	North Fork Lewis River	975,700
	1991, 1992	Lewis River	Lewis	Lewis River	1,885,900
	1990-1994	Lewis River	N F Lewis	North Fork Lewis River	1,801,800
	1996	Fish First Np	Lewis	Lewis River	55,872
	1997-2000	Fish First Np	Lewis	Lewis River	570,857
	1996, 1998	Lewis River	Lewis	Lewis River	2,074,841
	2001	Lewis River	Lewis	Lewis River	34 Adults
	1995-2001	Lewis River	Lewis	Lewis River	4,692,781
	2001	Speelyai	Lewis	Lewis River	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Creek	2,455,252

	1995-2001	Fallert Cr	Kalama	Fallert Creek	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Creek	615,463
	1999	Gobar Pond	Kalama	Gobar Creek	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Creek	332,281
Spring Creek	1993	Ringold	Carson	Spring Creek	68,900
	1993	Ringold	Kalama	Spring Creek	462,700
	1990	Ringold	Klickitat	Spring Creek	40,264
	1994	Ringold	L White Salmon	Spring Creek	336,268
	1993-1994	Ringold	Ringold	Spring Creek	596,274
	1992-1994	Ringold	Wind River	Spring Creek	2,250,000
Wind River	1991-1996	Carson NFH	Carson	Wind River	13,350,658
	1997-2001	Carson NFH	Carson	Wind River	7,096,346
Little White Salmon River	1991-1994	Little White Salmon NFH	Spring Creek	Little White Salmon River	2,757,539
	1992	Willard NFH	Carson	Little White Salmon River	869,952
	1991-1994	Little White Salmon NFH	Carson	Little White Salmon River	4,780,148
	1997	Little White Salmon NFH	Carson	Little White Salmon River	2,835,741
	1998-2001	Little White Salmon NFH	L White Salmon	Little White Salmon River	4,272,833
	1998-2001	Little White Salmon NFH	Urb-Mixed	Little White Salmon River	8,057,188
Drano Lake		Abernathy NFH	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek NFH	Urb-Bonn Dam	Spring Creek	14,348,604
	1991	Spring Creek NFH	Clackamas	Spring Creek	3,292,304
	1992-1996	Spring Creek NFH	Spring Creek	Spring Creek	89,083,822
	1997-2001	Spring Creek NFH	Spring Creek	Spring Creek	70,435,986
Big White Salmon River	1991-1996	Big White Salmon NFH	Carson	Big White Salmon River	3,581,536
	1997-1999	Big White Salmon NFH	Carson	Big White Salmon River	2,795,464
	2001	Big White Salmon NFH	Methow	Big White Salmon River	1,238,764
	1997	Spring Creek NFH	Carson	Big White Salmon River	543,270
Deep River	1999-2001	Deep River	Cowlitz	Deep River	255,657
Abernathy Creek	1991-1996	Abernathy NFH	Abernathy Cr	Abernathy Creek	6,853,504
	1997-1999	Abernathy NFH	Abernathy Cr	Abernathy Creek	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz River	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton River	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz River	53,800

Toutle River	1991, 1993	Toutle	Cowlitz	Green River	641,382
	1995	North Toutle	Toutle	Green River	1,412,100
	1995	North Toutle	Washougal	Green River	1,086,100
	1995- 2001	North Toutle	Cowlitz	Green River	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis River	1,229,262
	1994	Lewis River	Kalama	North Fork Lewis River	975,700
	1991, 1992	Lewis River	Lewis	Lewis River	1,885,900
	1990-1994	Lewis River	N F Lewis	North Fork Lewis River	1,801,800
	1996	Fish First Np	Lewis	Lewis River	55,872
	1997-2000	Fish First Np	Lewis	Lewis River	570,857
	1996, 1998	Lewis River	Lewis	Lewis River	2,074,841
	2001	Lewis River	Lewis	Lewis River	34 Adults
	1995-2001	Lewis River	Lewis	Lewis River	4,692,781
	2001	Speelyai	Lewis	Lewis River	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Creek	2,455,252
	1995-2001	Fallert Cr	Kalama	Fallert Creek	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Creek	615,463
	1999	Gobar Pond	Kalama	Gobar Creek	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Creek	332,281
Spring Creek	1993	Ringold	Carson	Spring Creek	68,900
	1993	Ringold	Kalama	Spring Creek	462,700
	1990	Ringold	Klickitat	Spring Creek	40,264
	1994	Ringold	L White Salmon	Spring Creek	336,268
	1993-1994	Ringold	Ringold	Spring Creek	596,274
	1992-1994	Ringold	Wind River	Spring Creek	2,250,000
Wind River	1991-1996	Carson NFH	Carson	Wind River	13,350,658
	1997-2001	Carson NFH	Carson	Wind River	7,096,346
Little White Salmon River	1991-1994	L White Salmon NFH	Spring Creek	Little White Salmon River	2,757,539
	1992	Willard NFH	Carson	Little White Salmon River	869,952
	1991-1994	L White Salmon NFH	Carson	Little White Salmon River	4,780,148
	1997	L White Salmon NFH	Carson	Little White Salmon River	2,835,741
	1998-2001	L White Salmon NFH	L White Salmon	Little White Salmon River	4,272,833
	1998-2001	L White Salmon NFH	Urb-Mixed	Little White Salmon River	8,057,188
Drano Lake		Abernathy NFH	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek NFH	Urb-Bonn Dam	Spring Creek	14,348,604

	1991	Spring Creek NFH	Clackamas	Spring Creek	3,292,304
	1992-1996	Spring Creek NFH	Spring Creek	Spring Creek	89,083,822
	1997-2001	Spring Creek NFH	Spring Creek	Spring Creek	70,435,986
Big White Salmon River	1991-1996	Big White Salmon NFH	Carson	Big White Salmon River	3,581,536
	1997-1999	Big White Salmon NFH	Carson	Big White Salmon River	2,795,464
	2001	Big White Salmon NFH	Methow	Big White Salmon River	1,238,764
	1997	Spring Creek NFH	Carson	Big White Salmon River	543,270

Lower Columbia River spring-run chinook salmon (Oregon)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Youngs Bay	1991-1992	Cedc	Clackamas	Youngs Bay	242,534
	1994	Cedc	North Santiam	Youngs Bay	301,361
	1992	Cedc	Willamette	Youngs Bay	301,786
	1996	Youngs Bay	Clackamas	Youngs Bay	97,945
	1995-1999	Youngs Bay	Willamette	Youngs Bay	3,114,060
	1996	Youngs Bay	South Santiam	Youngs Bay	276,493
Lower Columbia River	1996	Blind Slough	South Santiam	Blind Slough	199,389
	1995-2002	Blind Slough	Willamette	Blind Slough	1,457,655
	1996	Tongue Pt	South Santiam	Tongue Point	242,319
	1997-2000	Tongue Pt	Willamette	Tongue Point	1,029,850
Klaskanine River	1991	Cedc	Clackamas	South Fork Klaskanine River	119,627
	1994	Cedc	North Santiam	South Fork Klaskanine River	109,974
	1992, 1997	Cedc	Willamette	South Fork Klaskanine River	238,316
	1996	Cedc	South Santiam	South Fork Klaskanine River	76,618
Multnomah Channel	1997-1998	Step	McKenzie	Little Willamette River	123,134
Sandy River	1991-1994	Clackamas	Clackamas	Sandy River	1,316,973
	1991-1993	Clackamas	Clackamas	Salmon River	594,656
	1995-2002	Clackamas	Clackamas	Sandy River	3,539,458
Hood River	1991-1992	Bonneville	Lookingglass	Hood River	288,727
	1993-1995	Bonneville	Deschutes	Hood River	245,209
	1996-2001	Various (3)	Deschutes	Hood River	677,652
	2000-2002	Parkdale	Wild Origin	Hood River	101,883
	2000	Parkdale	Hood River	Hood River	4,126

Lower Columbia River up-river bright chinook salmon (Washington)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Little White Salmon River	1991-1993	L. White Salmon NFH	Urb-Eggbank	Little White Salmon River	8,758,842
	1994-1996	L. White Salmon NFH	Carson	Little White Salmon River	8,453,502
	1994-1996	L. White Salmon NFH	Carson	Little White Salmon River	1,225Adults
Spring Creek	1994	Ringold	Urb-Bonn Dam	Spring Creek	4,217,491

Note: "up-river bright" chinook salmon are not in the Lower Columbia River chinook salmon ESU.